2004 Sustained Yield Calculation

State of Montana
Department of Natural Resources

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Finally, we acknowledge the contributions of Dave Mason, founder of our firm in 1921. His early and zealous advocacy for sustainable forest management practices have had long lasting impacts on how our society views and manages our forest resources.

2004 Sustained Yield Calculation
For Lands Managed by the
Montana Department of Natural Resources and Conservation

Executive Summary

Pursuant to MCA 2003 77-5-222, a sustainable harvest level of 53.2 MMbf has been calculated for forest lands managed by the Montana Department of Natural Resources and Conservation.

This sustainable yield calculation meets all of the administrative rules adopted by the State Land Board in September 2003, the objectives outlined in the 1996 State Forest Land Management Plan, as well as other polices, goals and objectives specified by the Department.

There is excess inventory on the state forest lands. Annual harvest could be increased to 58.4 MMbf for 70 years before falling back to the 53.2 MMbf sustainable yield level. Accelerating the harvest would provide more revenue to the trust beneficiaries (a 15% increase in Present Net Value) and move the forest toward the desired future condition at a rate similar to the strict non-declining yield harvest level of 53.2 MMbf.

The 53.2 MMbf sustainable yield is about 26% greater than the 42 MMbf sustainable yield calculated in 1996. The increase is attributed to a more complete inventory, an increase in manageable acres, better inventory data, consideration of a wider variety of management opportunities, and structural differences between the forest models used to make the calculation.

The 53.2 MMbf sustainable yield is 55% of the maximum biological potential of 95 MMbf. The biological yield is achievable only if using optimal regimes harvested at the optimal time. Most of the reduction is due to limited management opportunities on about 13% of the state forest land, withdrawals for Grizzly Bear core and buffer areas, and decreased productivity associated with uneven-aged management regimes. A variety of other management constraints had a lesser impact on potential harvest levels. This report estimates the incremental cost, in terms of both harvest levels and Present Net Value, of each set of management constraints.

1 Purpose, Need and History

The Trust Land Management Division of the Montana Department of Natural Resources and Conservation (DNRC) manages in trust for ten trust beneficiaries 726,638 acres of forest land. In September 2003, the State Land Board adopted a set of administrative rules guiding DNRC management of forests.[1] These rules specify management objectives, regulate how and where timber harvest can take place, and establish standards and guidelines designed to protect habitat for specific wildlife species, while still maintaining the Department's ability to generate revenues for the beneficiaries of the Trust.

MCA 2003 77-5-222 (Appendix H) directs the Department to calculate a sustainable yield that takes into account the most recent data available and the new administrative rules. Sustainable yield is:

> *"…the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth."* ***(MCA 77-5-221)***

Periodic recalculation of sustained yield is necessary to incorporate changes in management intensity or emphasis, or as new laws and regulations come into play.

The DNRC contracted with Mason, Bruce & Girard, Inc. (MB&G) to perform the sustainable yield calculation. Established in 1921, MB&G is a natural resources consulting firm located in Portland, Oregon. MB&G has performed similar calculations for a variety of federal, state, private and tribal landowners across the US. MB&G worked closely with DNRC staff on this project. A list of contributors is found in **Appendix I.**

A draft of this report was made available to the public on September 1, 2004. The State Land Board considered the draft report at its September 20, 2004 meeting and deferred action until its October 18, 2004. In the meantime, the DNRC met with interested parties, received comments, and prepared responses to comments. **Appendix J** outlines the DNRC's public involvement activities with respect to this effort. **Appendix K** contains the DNRC's response to the topics most frequently raised during the public involvement process. A more complete response to questions is available from the DNRC.

At its October 18, 2004 meeting, the State Land Board unanimously voted to adopt a 53.2 MMbf sustainable harvest level.

This report explains how the 53.2 MMbf harvest level was calculated.

[1] ARM 36.11.401 through ARM 36.11.450.

1.1 Purpose of the State Forest Trust Lands

The State Forest Trust Lands are managed by DNRC in trust for beneficiaries. DNRC must manage these lands to,

> *"produce revenues for the trust beneficiaries while considering environmental factors and protecting the future income-generating capacity of the land."*[2]

1.2 Prior Sustainable Yield Calculations

DNRC has calculated a sustainable yield twice in the recent past, as shown in **Table 1.1**.

Table 1.1
Past Sustainable Yield Calculations

Year	Sustainable Yield Calculation	Acres included in the calculation
1983[3]	50.0 MMbf	399,700
1996	42.164 MMbf	363,769

The last sustained yield calculation was completed in December 1996 by Dr. James Arney of Forest Biometrics.[4] That study determined that the annual sustainable harvest level was 42.2 MMbf.[5]

From FY1997 through FY2003, the DNRC based the timber sale program on the 1996 calculation. In 2003, the Legislature directed the DNRC to sell 50 MMbf annually.[6] The annual sale program since 1994 is shown in **Table 1.2**[7]

[2] Mission Statement, Trust Lands Management Division, Montana Department of Natural Resources
[3] Sheartl, Dick, Montana Department of Natural Resources, *Allowable Cut Report*, August 26, 1983
[4] Arney, James D., *The Annual Sustained Yield of Montana's Forested State Lands*, December 1996.
[5] Mbf – thousand board feet; MMbf – million board feet; Bbf – Billion board feet, all in Scribner measure. A typical log truck holds 4-5 Mbf.
[6] 77-5-222 MCA
[7] Note that **Table 1.2** shows volume *sold*, not volume *harvested.* While revenues ultimately flow to the beneficiaries based on harvest, the volume sold is a more direct measure of DNRC annual timber sale effort.

Table 1.2

Volume sold from State Lands, FY 1994-2004
(Mbf, sawtimber)

FY	Mbf Sold
1994	34,500
1995	30,800
1996	35,700
1997	41,900
1998	41,260
1999	42,800
2000	44,560
2001	49,272
2002	43,607
2003	43,041
2004	50,800

1.3 Need for an Updated Sustainable Yield Calculation

Policies, management practices and data have changed since the 1996 calculation, making a recalculation timely. Important changes include:

- HB 537 (codified as Montana Code Annotated §77-5-222) was passed by the 2003 Legislature directing the department to conduct a new sustainable yield study

- The DNRC's inventory database system (SLI) now includes data that were not available in 1996, and has been updated to reflect management since 1995.[8] Specifically, 284,000 acres of forest land for Central, Southern, Eastern and Northeastern Land Offices have been added to the SLI inventory.

- New or updated SLI inventory data has been collected for 346,000 acres in the Northwest and Southwest Land Offices since 1995.

- The entire SLI inventory stand map and associated database has been incorporated into the Geographic Information System (GIS).

- New administrative rules specify more explicitly how the DNRC will manage State Trust Forests. The 2003 rules, for example, more specifically define management objectives with respect to certain wildlife species. The new rules also clarify how DNRC will manage timberland in certain sensitive areas.

- A broader array of vegetation management regime choices is considered in this calculation.

This calculation is timely, furthermore, since the DNRC is in the process of evaluating a Habitat Conservation Plan (HCP). As part of the federal decision making process, an Environmental

[8] SLI – Stand Level Inventory – The DNRC's stand-level inventory system.

Impact Statement (EIS) will be prepared. At this point, we anticipate that this sustainable harvest calculation will form the basis of the No Action Alternative examined in the EIS.

1.4 Uses & Limitations

This sustainable yield calculation is based on a great deal of spatial and tabular data about the forest. Some of the data are site specific, other data are more generalized. A Forest Management Model was designed to address strategic level questions.[9] Specifically, the model was designed to provide a reasonable and defensible estimate of:

- A sustainable harvest level from DNRC lands, along with associated revenues and costs;
- The impacts of management on specific wildlife habitat conditions; and
- A projection of forest conditions across DNRC lands.

Given the data and effort invested in the modeling effort, it may be tempting to try to use the model for purposes beyond the stated objectives. As discussed below, however, the model has limited spatial capabilities. Readers are cautioned against trying to use the model for more tactical, operational or site-specific tasks. While the model might be used to analyze general management strategies, for example, it should not be used to locate harvests into specific stands or under specific management regimes.

[9] Strategic questions: How should we manage this forest to meet objectives? What kinds of management regimes are most compatible with our objectives? How important are current investments for meeting future harvest objectives?
Tactical questions: Which roads should we build and which stands should we harvest first?
Operational questions: Where should the landing go?

2 Data and Methods

This section provides a general overview of the data and methods used to calculate the sustainable yield. Section 3 provides information more specific to the Forest Management Model created for this sustainable yield calculation. The Appendixes contain details about the data used in the model.

2.1 *Overview of the Forest Management Model*

Given a specific management objective, one could identify a "best" management regime for any particular timber stand. The "best" regime for producing harvest revenues in a particular Ponderosa Pine stand, for example, might call for a commercial thin at age 80 and a final harvest at age 120.

The problem facing State land managers, however, is much more complicated. The "best" set of management regimes must provide a flow of outputs and revenues sustainable over a long time period, while creating or maintaining desirable forest conditions. What might be the "best" choice at the stand level, may not be "best" when viewed at the landscape level over a long time horizon. Given the spatial and temporal complexities, forest managers turn to computer models to help identify the "best" course of action.

This sustainable yield calculation was made with a Forest Management Model that looks across time (175 years) and space to find the best set of forest management regimes, given the objectives and constraints facing DNRC land managers.

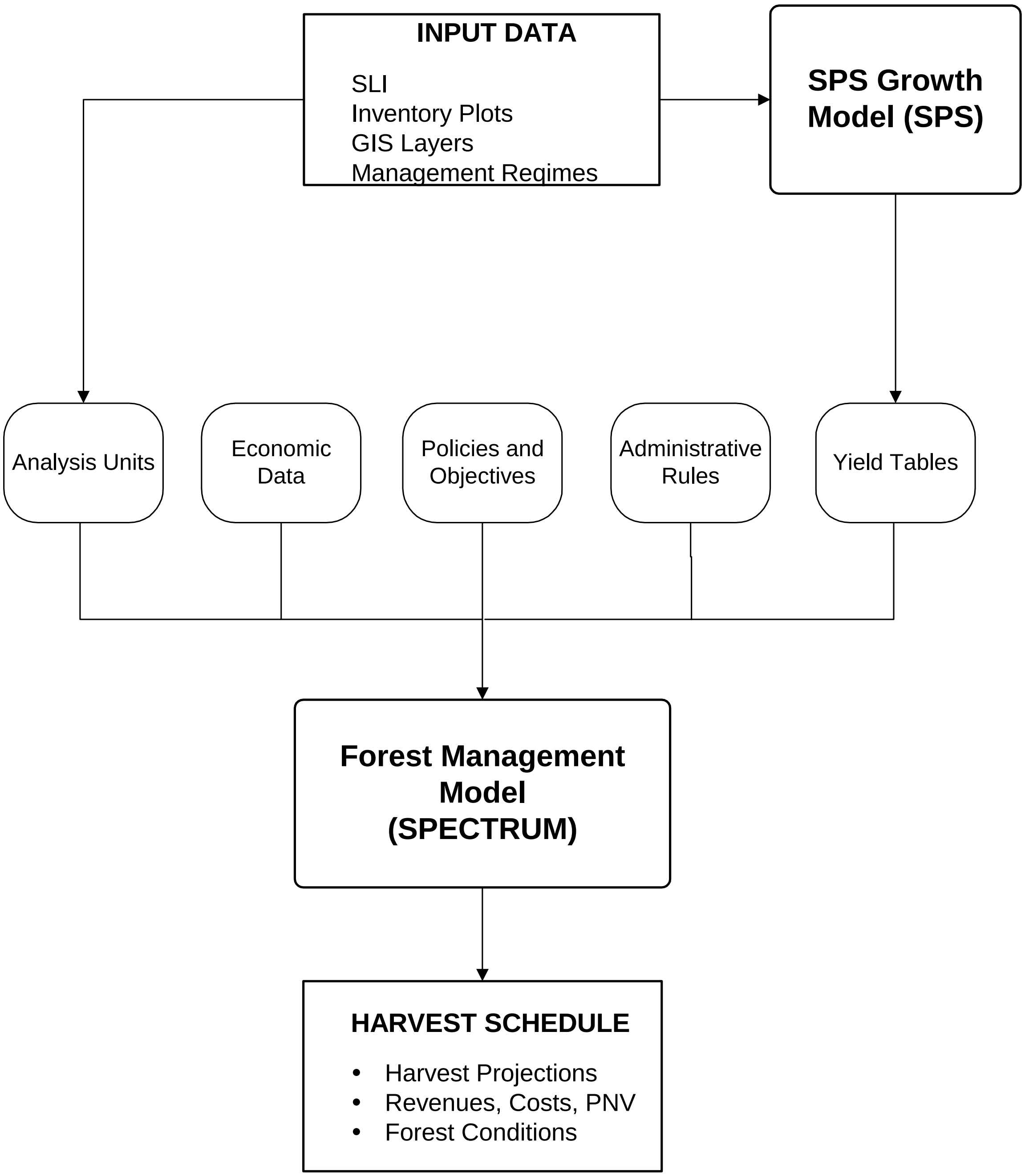
To calculate and evaluate a sustainable harvest level, we used Spectrum – a linear programming model developed and supported by the US Forest Service.[10] We selected an optimizing model because: (a) it is compatible with the objectives of the DNRC as managers of the State's forest trusts – maximizing sustainable revenue while maintaining a healthy and diverse forest; and (b) it lends itself to analysis of alternatives, and to the incremental analysis of the cost of various management decisions – tasks important to both the sustainable yield calculation itself, as well as the upcoming HCP effort.

Linear programming models have been used extensively for similar tasks by forest industry, non-industrial private timberland owners, States, Tribes and the federal government for many years. Spectrum is a linear programming model that provides a flexible platform for building Forest Management Models and has been used extensively by a wide variety of land managers to model and study a wide variety of forest management questions.

Figure 2.1 presents a flowchart of the Forest Management Model. The remainder of Section 2 presents a general overview of the Forest Management Model and the data used to build the model. Section 3 provides a more in-depth view of the model, and Section 4 presents the results of the analysis. Readers are encouraged to refer back to **Figure 2.1** frequently.

[10] http://www.fs.fed.us/institute/planning_center/spec_update.html.

Figure 2.1
Overview of Forest Management Model



2.2 Land base

Detailed information about the State forest trust land is fundamental to the calculation of a sustainable yield. Much of the spatial information required for the Forest Management Model originates in the DNRC's Stand Level Inventory (SLI). Other spatial information was derived from other sources specifically for this project. This section describes the available information and how it was used

2.2.1 The Stand Level Inventory (SLI)

The DNRC's SLI database identifies and holds information about the land type in over 34,000 polygons, including 27,900 polygons of forest land. Each polygon referred to as a "timber stand" or simply a "stand" is relatively homogenous with respect to species, size and stocking.

The SLI is linked to spatial data through a Geographical Information System (GIS). The DNRC uses the SLI and associated GIS layers on a regular basis to maintain information about forested resources, analyze natural resource questions, and to support the work in the field.

Important to the sustainable yield calculation is SLI information about species, size, stocking level, potential vegetation classes, productivity, and management objectives. These and other timber stand characteristics stored in the SLI are based on observations made during a "walk through" inventory – the SLI does not contain cruised, plot-level data.

Key to the sustainable harvest calculation is the timber type for each timber stand. The timber type is comprised of codes describing the primary species class, a size class and stocking class. A timber type code of DF9W, for example, means that the primary species is Douglas-fir, the size class is sawtimber and the stand is well stocked.

The first stands surveyed for the SLI were assigned a timber type in 1984. Most timber types, however, were assigned during 1996-2003. Harvested and burned stands are updated on a continual basis. Some stands have been updated or re-inventoried two or three times since they were first entered into the SLI database. We evaluated whether the codes should be updated to account for growth between size classes and ultimately determined that net changes between timber types would have been small.

The SLI was updated for all harvest activity and fires as of January 2003. DNRC forest land burned in the summer of 2003 was not reclassified for this project.

Also important is the "appropriate vegetation" class or potential vegetation class.[11] This represents the desired stand composition and may be different from the current vegetation. A stand currently classified as Douglas-fir, for example, may have a potential vegetation class of Ponderosa Pine. This means that the desired future condition for the stand is one dominated by Ponderosa Pine. The management regimes in the model are designed to move the stand toward the desired condition.

[11] In the SLI, this is referred to as "appropriate vegetation." In the Forest Management Model and in this document, this is called "Potential Vegetation Class" or "PotVeg."

2.2.2 Other Information about The Timberland Base

While much of the information needed for the sustainable harvest calculation can be found in the SLI, some information needed for the calculation does not exist in the SLI and was generated specifically for this project. The SLI, for example, does not identify riparian acres, road acres, the grizzly bear status of each stand, or whether the stand exists in a sensitive watershed. Information about these characteristics was generated as discussed below.

- Riparian areas

The 2003 administrative rules specify management requirements for riparian areas. Riparian buffer widths, and management within those buffers, differ depending on whether certain fish species are present or absent. Fish presence was based on occurrence of native, cold water fish species.

A riparian buffer was constructed for this analysis using the 1:24,000 stream layer and Montana Fish, Wildlife and Parks survey data about fish presence. These layers were combined using the GIS. The fish/presence/absence data were extended beyond the reaches surveyed using the GIS.

Using the GIS, riparian buffers were delineated based on the Unit Office and the fish presence/absence data, as shown in **Table 2.1.**

Table 2.1
Riparian Buffer Widths
(feet on each side of the stream)

Unit Office	Fish Absent	Fish Present
Libby, Stillwater, Swan	50	120
Kalispell, Plains, MSO, CLW, Ham	50	100
Anaconda and Eastside LOs	50	80

There are about 12,000 acres in riparian areas adjacent to streams where fish are present and 15,000 acres where fish are absent.

- Road acres

The sustainable harvest calculation is based on acres available and capable of growing timber. The SLI and the associated GIS stand layer have acreages for the entire stand polygon, but do not report acres in road clearings. Road clearing acres for each stand polygon were calculated using a GIS process. Road clearings were calculated using a total width of 28 feet on slopes less than 40% and 56 feet on slopes greater than 40%.

The estimated road acres were subtracted from each stand polygon, leaving the net timberland acres. More than 17,000 acres of timberland were removed from the timberland base based on this process.

- Grizzly Bear areas

SLI stands were identified as to whether they fall within the Grizzly Bear security core and associated buffer areas. These areas were established by interim guidance developed by the DNRC Forest Management Bureau in October 1995, and subsequently adopted in the 2003 Forest Management Rules.

Acres in the Grizzly Bear visual corridors were derived by buffering all open roads in the Grizzly Bear recovery area in the Swan River State Forest, the Stillwater and Coal Creek State Forests. In the model, overlaps are resolved in favor of the core & buffer areas, the visual corridors and the recovery areas, in that order.

There are about 49,000 acres of timberland in the core and buffer areas, about 3,800 acres in the visual buffers, and another 104,000 acres in the remainder of the recovery area.

- Sensitive Watersheds

The DNRC identified stands located in sensitive watersheds. These are watersheds located in western Montana that may be sensitive to cumulative watershed impacts. Criteria for identifying these watersheds include:

Portion of the watershed under industrial forest ownership
Known extensive timber harvesting or stand replacement fire
Documented cumulative watershed effect concerns, problems, or previous analysis
Watershed issues, 303 (d) listing
Municipal watershed
Reference watershed

Nearly 111,000 acres are in sensitive watersheds. This process is similar to the one used to identify the sensitive watersheds included in the 1996 SYC.

2.3 Timber Inventory Information

The calculation of a sustainable yield is based on projections about how timber stands will grow and change over time, under different management regimes. These projections also provide information about stand conditions that are important for understanding impacts on other resources (e.g. number of large trees per acre, species composition, crown closure, etc.)

Fundamental input to most growth and yield models is a "stand table" for each timber type. The stand table can be thought of as a summarized list of the trees in the stand. With information about the species, size and number of trees in a stand, and any management applied to the stand, the growth model projects the stand into the future. The remainder of this section describes the process used to derive stand tables to be input into the growth and yield model.

2.3.1 Source of Stand Table Data

Although the SLI database contains a great deal of general information about the vegetation in each stand polygon, it does not contain stand table data. Stand tables for this project came from three sources:

- US Forest Service FIA data

The USFS periodically takes field measurements of timber stands as part of the National Forest Inventory Analysis (FIA) program.

The FIA inventory measures trees in a 10-point cluster of plots. We treated each point within the cluster as a separate "plot." We relied on all the available data collected on State lands.

The most recently available data is the 1988-89 survey. Much of this is the same survey data that was used in the 1996 inventory. For this effort, however, we used some plots in the Central and Eastern Land Offices that were not used in the 1996 SYC.

- DNRC Cruise data

In 1997 through 2002, DNR cruised 66 stands in the Southwest Land Office. We used measurements for these stands, along with the FIA plots, to create stand tables for the Southwest Land Office.

- DNRC estimated stand conditions

Neither the FIA plots nor the DNRC cruise data contained adequate data about younger stands for all forest types and stocking classes. For SLI stands classified as seedlings and saplings and some of the stands classified as poletimber size, we first described the species mix and average size of trees expected to be found on newly regenerated acres. These expectations were based on data, professional judgment and observation, and varied by site, PotVeg class and Land Office by regeneration method (e.g. natural regeneration versus planted). Applying a Weibull distribution function to the stand averages, we created a distribution of the trees expected to be in these younger stands. These distributions formed the beginning stand tables for the seedling and saplings, poletimber, and the new stands regenerated by the model within the planning horizon.

2.3.2 Deriving Average Stand Tables

The SLI stands were typed using criteria similar to the FIA typing criteria. The DNRC plots were assigned the type of the SLI stand they sampled. As a result, each plot was identified as to the primary species, size class and stocking class.

Plots were then grouped by Land Office, species group, size class and stocking class. If there were too few plots in a group, that group was combined with a similar group. Plots in each group were then averaged together using the SIS expander, resulting in an average stand table for each type.[12]

Table 2.2 shows a few records from a stand table for a medium stocked Douglas-fir sawtimber stand in the Northwest Land office.

Table 2.2[13]
Stand table records, example

DBHCLASS					
STAND	SPECIES	DBH	TPA	HT	CRN
10085	DF	7.4	13.393	26	35
10085	DF	7.9	11.751	60	35
10085	DF	8.4	10.394	61	35
10085	DF	9.5	8.126	47	65
10085	DF	9.6	7.958	60	35
10085	DF	9.8	7.636	63	25
10085	DF	9.8	7.636	63	35
10085	DF	10.3	6.913	63	35
10085	DF	11.5	5.546	54	65
10085	DF	12.1	5.009	62	35
10085	DF	12.7	4.547	76	35
10085	DF	13	4.34	68	35
10085	DF	13.2	4.209	63	25
10085	DF	13.6	3.965	74	35
10085	DF	14	3.742	63	65
10085	DF	14.8	3.348	82	25
10085	DF	15.1	3.217	79	75
10085	DF	16.4	2.727	82	35
10085	DF	18.4	2.166	80	70
10085	DF	19.4	1.949	80	65
10085	DF	21.3	1.617	88	75
10085	DF	21.3	1.617	89	75
10085	DF	26.2	1.068	69	70
10085	OH	9.7	7.795	64	25
10085	PP	29	0.872	116	15
10085	WL	22.2	1.488	92	25

The stand tables for the seedling and sapling size stands and the regenerated stands did not go through this process since there were insufficient FIA or DNRC plots in these types. Stand tables for these types were specified by the DNRC, based on a large number of regeneration surveys and field observations.

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[12] SIS is the Stand Inventory System, a software program used to manage stand-based inventories. The Expander is a module that averages stands together to produce average stand tables.
[13] DBH – Diameter at breast height; TPA – trees per acre; HT – height; CRN – crown ratio

From the SLI, we obtained a summary of stands based on timber type (species, size, stocking) by Land Office. Each existing type was assigned an average stand table. In most cases, there was an exact match on species, size, stocking. In some cases, there was no plot data, or not enough plot data, to make an exact match between the average stand tables and the existing stands. In that case, we selected the next best match.

The SPS growth model and the Forest Management Model use stand age as a way to keep track of time and to schedule management activities (e.g. planting, precommercial thinning, harvest entries, final harvest, etc.). Stand age is sometimes a nebulous concept given that many stands contain trees with a wide range of ages. Tree age, furthermore is a difficult and expensive measurement to collect, and as a result, is collected for only a small subset of trees. We reviewed the stand ages as calculated by the SIS Expander and found them to provide reasonable estimates for the purposes of modeling. These ages should not, however, be used to draw inferences about the "age" of the forest nor its status with respect to age-based old growth definitions. Procedures for tracking and projecting old growth stand conditions are found in Section 4.2.10.

Stands were assigned to a productivity class based on the productivity information stored in the SLI. **Table 2.3** shows how the SLI productivity estimates were grouped into classes. Each productivity class was assigned an average site index used in the growth and yield modeling process, as shown in **Table 2.4**. Roughly a third of the acres in each land office fell into each site index class.

Table 2.3
Productivity Class
(cf/ac/yr)

Area	Low	Medium	High
Eastside	20-30	31-39	40+
SWLO	20-65	66-70	71+
NWLO	20-65	66-96	97+

Table 2.4
Average Site Index by Class

Area	Low	Medium	High
Eastside	30	40	50
SWLO	50	55	60
NWLO	50	60	70

We made three copies of the stand tables and assigned one copy to each of the three site index classes. These became the initial stand tables grown forward with the SPS growth model.

2.3.3 Growth and Yield Projections

A timber growth and yield model called Stand Projection System (SPS) was used to project future timber volumes and forest conditions.[14] SPS was selected because it has been widely used in the Northern Rockies and because it provides results consistent with observations by DNRC foresters. SPS, furthermore, is similar in architecture, approach and pedigree to the model used in the 1996 SYC.

SPS projects tree growth primarily as a function of species, site, stocking and the size of the tree relative to other trees in a stand. An 18” DBH Douglas-fir, for example, grows faster in a stand heavy to 8” DBH trees than it does in a stand of 28” DBH trees. Trees grow faster in properly stocked stands than they do in over-stocked stands.

The SPS model can be calibrated to local conditions. Calibrations made for Idaho Department of Lands, using 30 years of growth plot data, were used for this project. Grand fir growth was further adjusted to meet DNRC expectations for Western Montana. The SPS clumpiness factor was set to 0.55 for existing stands and 0.80 for regenerated stands in Central and Eastside Land Offices, 0.6 for existing stands and 0.80 or 0.65, depending on the type, for regenerated stands in the Southwest and Northwest Land Offices.

The yield projections reflect improved growth from stocking control and proper tending of young stands. The yield projections, however, do not assume any growth increase from fertilization or improved planting stock. Overall, the projections are somewhat conservative compared to projections made by other land owners with similar land bases. The per acre yields projected for this SYC are comparable to those used in the 1996 SYC.

The SPS growth model calculates timber volumes based on localized taper equations. The SPS volumes, however, were replaced by volumes calculated using the tarif equations DNRC uses to calculate timber sale volumes. These equations are based on the following merchantability specifications: 16 foot log scale, 8 foot minimum log length, 1 foot stump, 7” minimum DBH and a 6” minimum top diameter outside bark. These merchantability specifications are slightly different than those used in the 1996 SYC, which used a 8” minimum DBH.

The SPS growth model projects growth and yield of commercial tree species. It does not project non-timber vegetation, nor does it project snags, coarse woody debris, etc.

2.3.4 Important Assumptions

There are a number of assumptions inherent to the process used to create the data for the Forest Management Model:

- The 1988-89 FIA inventory and the 1997-2002 DNRC plots provide a valid picture of average stand conditions within each timber type. The trees on the FIA plots have very likely changed over the last 15 years, and if those plots were re-measured and retyped today they may be typed differently. Even so, the past measurements reasonably represent the

[14] Mason, Bruce & Girard, Inc., 1996, *SPS User’s Guide.*

compositions of stands as they were typed then, and are a reasonable representation of the compositions of stands with those types today.

- Our typing of the FIA and DNRC plots was performed on the measurements taken by the cruisers – these are “calculated” types. The SLI typing is based on visual estimates made during the walk through inventory process and on photo interpretation – these are called “photo” types. Our assignment of average stand tables to SLI stands assumes that there is a good correlation between the photo types and the calculated types.

- Neither the photo interpreted types nor the calculated types take site class directly into account. We grew the average stand tables forward under three different site indexes. This procedure assumes that site-related effects are expressed through the differences in yield that the growth model produces because of variable productivity.

- We assume that the SLI accurately portrays the status of each timber stand. Unit foresters, for example, identified stands that could not be harvested because of operability and access issues. We assume that all stands not so designated are indeed available for harvest.

2.3.5 Limitations

Within the Forest Management Model, the average stand tables are used to represent the stand characteristics across all of the stands within a type. All of the well-stocked Douglas-fir sawtimber stands in the Northwest Land Office, for example, are assumed to have the same characteristics at the beginning of model runs – the model is unaware of any material differences between stands within a type.

As discussed below, the model is aware that some of these well-stocked Douglas-fir sawtimber stands are in Grizzly Bear core areas, some are in sensitive watersheds, some are in riparian areas, and so forth. In some cases, the future management of these stands may be affected by these designations. But for any given set of characteristics, the model is unaware of how many polygons contribute to the total acres or the spatial juxtaposition of the polygons. As a result, we are careful not to disaggregate the model solution to the stand level, nor to ask questions that presume more spatial detail than we have. We would not, for example, look to the model solution to identify a timber sale package, or to design the future transportation network.

Sensitivity testing suggests that there is a great deal of flexibility in the model. Similar harvest levels can be achieved in many ways.

3 Formulation of the Montana Forest Management Model

This section describes the structure, organization and operation of the Forest Management Model built for the sustainable yield calculation.

3.1.1 Structure of Forest Management optimization model

The Forest Management Model is a linear programming optimization model. The model finds an optimal solution, given a mathematical representation of management objectives and constraints.

The DNRC Forest Management Model seeks to optimize either the Present Net Value (PNV) of the harvest schedule or the timber harvest in the first five-year period. A wide variety of constraints reflect DNRC management polices and objectives, as well as physical limitations on management opportunities and capabilities.

The Forest Management Model projects activities, outputs and conditions for 175 years (35 five-year periods) into the future – about one and a half rotations. While the DNRC anticipates that the SYC will be recalculated every ten years, a long planning horizon is important to help ensure that management strategies and harvest levels implemented during the next ten years do not have any unintended or unforeseen long-term consequences.

The remainder of this section describes the components of the Forest Management Model.

3.1.2 Analysis Areas

Forest land is represented in the model as a set of "Analysis Units" (AUs). Analysis Units are non-contiguous parcels of land, homogenous with respect to factors that: (a) affect outputs, costs and revenues (e.g. timber species, size stocking, site); (b) affect management choices, opportunities and constraints (e.g. riparian status, T&E habitat designation, etc.); and (c) are important from an administrative stand point (e.g. Land Office).

Since the Forest Management Model will be used for the HCP as well as the sustainable yield calculation, the model has more strata than are needed for the sustainable yield calculation. The stratification for the Forest Management Model is summarized below.

Level 1:	Administrative Area (Eastern LOs, Central LO, Southwest LO, Stillwater, Swan, and Other NW units)
Level 2:	Elevation class, Grizzly Bear designation, Bald Eagle habitat, sensitive watershed, administrative availability, old growth characteristics
Level 3:	Riparian status
Level 4:	Potential vegetation class
Level 5:	Timber site index class
Level 6:	Timber species, size class and stocking class

Conceptually, the Analysis Units are formed by overlaying a number of maps. Each of the individual polygons resulting from the overlay has a complete set of characteristics for Level 1 through 6. Polygons with identical characteristics are grouped together in the Forest Management Model into Analysis Units. Each Analysis Unit, therefore, has a unique set of characteristics.

Appendix C summarizes acres by classification by land office.

3.1.3 Management Regimes

The Forest Management Model contains a number of alternative management regimes for each Analysis Unit. Each management regime describes the activities, outputs, costs, revenues and forest conditions resulting from managing the Analysis Unit as specified. One regime, for example, might apply even-aged management techniques to a given Analysis Unit, scheduling a precommercial thinning, a commercial thinning, a final harvest, and then a similar set of practices on the regenerated stand. An alternative management regime might enter the Analysis Unit once every thirty years to harvest some of the trees, leaving a residual stand designed to meet some management objective.

Details about the management regimes can be found in **Appendix D .** A brief summary of the design of the regimes follows.

- Maintenance – no harvest

No active management is scheduled under this regime. This regime is assigned to areas that cannot or will not be managed. It may also be an appropriate choice given other management objectives, as shown in **Appendix B**.

- General even-aged regimes

Applies combinations of standard even-aged management practices, including precommercial thinning, one commercial thin, and final harvest. Final harvest includes clearcut, seed tree and shelterwood silvicultural systems. Leave trees and down woody material are left at final harvest. The new stand is established either through planting or natural regeneration.

- General uneven-aged regimes

Stands are entered on a 30 year cycle (also a 50 year cycle on the Eastern Land Offices). Harvest reduces the basal area to a specified target, leaving a specified number of large trees, if they are available. Harvest is across diameter classes. Harvest generally favors retention of shade-intolerant species, appropriate to the potential vegetation classification. With some Potveg groups the shade-tolerant species are favored for retention. The residual basal area is generally less under these regimes than under the other uneven-aged management regimes, such as the regimes for riparian, old growth or eagle nest sites.

- Riparian regimes

There are two sets of riparian regimes – the regime used in riparian areas where fish are present leaves more basal area than the regime that is used in riparian areas where fish are not present.

- Eagle habitat regimes

These regimes are designed to be compatible with Eagle nest areas. Stands are entered on a 30 year cycle. Harvest reduces the basal area to a specified target, leaving a specified number of large trees, if they are available. Harvest is across diameter classes. The residual basal area is generally higher under this regime than under the other uneven-aged management regimes. In eagle primary use areas any uneven aged regime is compatible.

- Old growth regimes

These regimes are designed to apply active management to stands identified as old growth. Stands are entered on a 30 or 50 year cycle. Harvest reduces the basal area to a specified target, leaving a specified number of large trees, if they are available. Harvest is across diameter classes. Some old growth acres may be scheduled for a final harvest during the planning horizon.

There are two sets of old growth regimes in the model. One set is based on a 30 year entry cycle and leaves the minimum number of large trees. The other set enter the stand on a 50 year cycle and leaves more large trees per acre than required to meet the Green et.al. (1992) old growth definitions.

On the Eastern Land Offices, the General Uneven-aged regimes provide conditions meeting the old growth definitions.

All of the uneven-aged regimes were designed to move the stand toward the DFC, as described by the PotVeg class. In an AU where PotVeg = Ponderosa Pine, for example, the Ponderosa Pine is favored for retention in each entry.

Many of the management regimes are compatible with more than one management objective. The riparian regimes, for example, are compatible with management objectives in the Eagle Nest Areas, and the Eagle Primary Use areas. The general uneven-aged management regimes are compatible with the management objectives for riparian areas where fish are absent.

Appendix B contains a matrix showing the compatibility of the management regimes with various management objectives.

No active management is scheduled for non-commercial forestland or for hardwood stands.

3.1.4 Yield Projections

Applying management activities to forested lands results in costs, outputs, revenues, and various forest conditions, all of which become input into the Forest Management Model. Section 2.3.3 describes the SPS growth model in detail. This section provides more information about the yield projections themselves.

For each Analysis Unit, we generated a number of yield tables, each reflecting a different management regime. Overall, we generated and evaluated over 12,000 individual yield tables. Yield tables that did not generate entries with at least 1.0 Mbf/acre were not used. Close to 9,000 yield tables were found acceptable and were brought into the Forest Management Model.

The SPS growth model returns a complete stand table for each analysis unit, under each management regime, at each five-year period. Information important to the sustainable yield calculation and for the models needed for the upcoming HCP analysis was summarized and imported into the Forest Management Model. The summarized data included:

- Net green Scribner volume per acre for seven different timber species groups (DF, PP, WL, LPP, WW, RC, Other)
- Trees per acre in six different size classes (<7" DBH, 7-9"DBH, etc.)
- Percent crown closure, calculated as suggested by Dealy.[15]
- Old growth characteristics – whether the stand meets the Green et.al. (1992) old growth definition for each of 11 different old growth types.
- Basal area

These characteristics were summarized for each analysis unit, under each management regimes.

3.1.5 Economic Data

The Forest Management Model uses economic data to ensure that the selected set of management regimes is economically efficient. By that we mean that given the objectives and constraints imposed on the model, each solution represents the strategy that provides the highest present net value.

In the model, timber harvests produce timber revenues, and incur management costs. Timber revenues are input by major species group, and are based FY 1990-2002 averages specific to each Land Office, as shown in **Table 3.1**. Annual real price trends of 0.5% were applied for the first 50 years of the planning horizon, based on price projections found in the most recent US Forest Service RPA Assessment.[16]

Table 3.1
1990-2002 Average Stumpage Price by Land Office
($/Mbf)

	Central	Eastern	Northwest	Southwest
Douglas-fir	174	155	210	189
Ponderosa Pine	210	189	255	230
Western Larch			238	214
Lodgepole Pine	164	146	198	178
Whitewoods	183	163	221	199
Red Cedar			660	639

Most of the DNRC management costs are represented in the model as fixed costs of approximately $7/acre/year. Additional fixed costs were added for harvest levels above 50 MMbf, 60 MMbf and 70 MMbf. In addition to the fixed costs, variable costs were assigned for sale preparation, planting and precommercial thinning. These costs are based on DNRC recent historical averages and vary by Land Office.

The Present Net Value calculations were made using a 4% discount rate, as specified by the DNRC.

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[15]Dealy, J.E. 1985, *Tree basal area as an index of thermal cover for elk*, Res. note PNW-425.
[16] Haynes, Richard W., *An Analysis of the Timber Situation in the United State: 1952 to 2050*, Gen. Tech. Rep. PNW-GTR-560. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 254 p.

3.1.6 Objectives and Constraints

The Forest Management Model is an optimization model that selects management regimes for each Analysis Unit in a manner that meets management objectives in the most economically efficient manner. Objectives and constraints used in the model reflect DNRC goals, objectives, policies and administrative rules. We change these objectives and constraints between model runs to evaluate alternative management decisions, and/or to evaluate the cost of management decisions.

A summary of the objective functions and constraints follows:

- Objective functions

The Forest Management Model has three objective functions: maximize present net value over the entire planning horizon, maximize total harvest over the entire planning horizon, maximize harvest volume in period 1.

We found that the sustainable yield calculation did not differ significantly between the different objective functions. Ultimately, we relied on the maximize present net value objective function for the sustainable yield calculation because it would provide the most long-term value to the trust, given the limitations required by environmental, biological, and management laws and legal precedence that guide the Forest Management Bureau's operations. All figures in this report are from runs that maximize present net value.

- Constraints

Constraints generally reflect the limitations set out in the SFLMP and the administrative rules developed for implementing that plan.

> <u>Harvest flow</u> constraints regulate the relationship between timber harvest in one period and the next. Most runs were made with a non-declining yield (NDY) constraint – the harvest in any period must be greater than or equal to the harvest in the prior period. In some runs, however, harvest levels were allowed to fluctuate between a specified harvest floor and harvest ceiling.
>
> <u>Allocation constraints</u> force certain acres to be managed under specific management regimes. Deferred areas and Grizzly Bear Core areas, for example, can only be managed under the Maintenance regimes (no scheduled harvest). Eagle Primary Use areas can only be managed under regimes compatible for those areas, as shown in the compatibility matrix found in **Appendix B.**
>
> <u>Forest conditions constraints</u> either limit the number of acres in a certain condition, or require a minimum number of acres in a condition. In sensitive watersheds, for example, no more than 25% of the acres can be less than 40 years old at any point in time.
>
> <u>Forest Plan constraints</u> direct management to be consistent with the 1996 SFLMP. These constraints move the forest toward a desired future condition by specifying the maximum acres that can be managed under certain regimes.
>
> <u>Implementation constraints</u> are used to help ensure that the model produces a solution that can be implemented. These constraints smooth fluctuations of certain management actions over time and space.

4 Results

The Forest Management Model was used to calculate a sustainable yield to guide DNRC management over the next ten year period. The model representing the final sustainable yield calculation was built incrementally by adding one set of constraints at a time. This incremental approach had two purposes. First, it allowed us to see that each new set of constraints had a reasonable and explainable impact on the harvest schedule. Second, it provides the incremental cost of each set of constraints.

Table 4.1 lists the model runs discussed in this report. Each run was made by adding one set of constraints to the previous run. The differences between subsequent runs, therefore, can be viewed as the incremental "cost" of those constraints.

Table 4.1
Forest Management Model Runs

Run	Constraints added to this run	Comments
BM001	Non-declining yield	Maximum biological potential
BM002	Withdraw "deferred" acres; Subtract snag recruitment volume	
BM003	Relax non-declining yield constraint	Identify opportunities to increase harvest in the short run, without affecting long run production
SYC001	Non-declining yield Special management in riparian areas	
SYC002	Withdraw Grizzly Bear core and buffer areas	
SYC003	Limit final harvest in sensitive watersheds	
SYC004	Special management in Eagle areas	
SYC005	Special management in Grizzly Bear visual buffers.	
SYC006	Special management in old growth stands	
SYC007	1996 SFLMP constraints	
SYC008	Implementation constraints	
SYC009	Allow harvest to fluctuate ±10% from SYC008	Identify opportunities to increase harvest in the short run, without affecting long run sustainability
SYC010	Allow harvest to rise 10% above SYC008, but never fall below SYC008	Identify opportunities to increase harvest in the short run, without affecting long run sustainability

The following sections summarize the results of each model run. **Appendix A** contains a set of graphs displaying the results of each run in more detail. First, however, some more background about the model runs is in order.

4.1 Qualifications

The Forest Management Model is based on a simplification of the forest land base, the inventory on that land, and the management regimes that DNRC might use to manage that land. Data limitations preclude a more site-specific model design. The model solutions, therefore, are intended to provide a reasonable expectation of outputs, revenues, costs and conditions. The model results, however, must not be construed as providing precise direction about which stands to cut when.

Harvest in the Forest Management Model is driven by an objective to maximize present net value (PNV). This ensures that each model solution is economically efficient. The PNV calculation is similar to a discounted cash flow calculation typically found in an appraisal, and readers might be tempted to use it as such. We urge caution in this respect, given the simplifications made for the modeling process.

The last model runs, SYC008, SYC009 and SYC010, are the only runs that include constraints designed specifically to make the solution more implementable. These constraints reduced the sustainable yield calculation by 3.3 MMbf and $12 million. Since the intermediate runs do not have these constraints, it may be difficult to carryout on the ground the management activities specified in the intermediate runs. The results from the intermediate runs, therefore, should be used to understand and compare the impacts of each constraint set, not as a commitment to a harvest level if those were the only constraints in the model.

The order in which the runs are made can affect the impact of the individual constraints because of overlapping mitigations, e.g., a bald eagle nest may exist within a riparian management zone. As a result, if the bald eagle constraints are added after the riparian constraint its yield and PNV consequences are reduced. PNV (and volume) comparisons from one run to another represent incremental changes according to the order of entry into the model. For example, placing the SFLMP constraints first in the order of entry would yield a different estimate of PNV effects.

4.2 Discussion of Model Results

Most of the early model runs were solved under two and sometimes three objective functions: maximize Present Net Value, maximize harvest in the first period, or maximize harvest across the entire planning horizon.[17] Results showed that the choice of objective function had little impact on the solution, once a non-declining yield constraint was added to the run. The maximum PNV runs, for example, had slightly better present net value, but slightly lower first period harvests, than the runs that maximized timber in period 1. The runs that maximized harvest over the entire planning horizon were very similar to the runs that maximized timber in period 1. Some of the later runs were only solved with the maximize PNV objective function. To simplify the discussion here, we show only the maximize PNV results for each model formulation. Analysis of alternative objective functions provided DNRC with additional insight into the forest land base and its ability to produce a sustainable yield over time.

[17] The runs that maximized timber were subsequently "rolled over" to maximize PNV, given the harvest level calculated in the first run. This procedure ensures that the PNV can be compared between runs with different objective functions.

Appendix A shows four graphs summarizing each run. A brief explanation of each graph follows:

- Volume Harvested by Species – shows volume scheduled for harvest each period by species. The red line is the sustainable harvest level. The difference between the sum of the bars and the red line is the volume left behind at final harvest for snag recruitment. The Long Term Sustained Yield (LTSY) reported here is the sustainable harvest projected by the model, past the 175 year planning horizon.

- Inventory, Harvest and Growth – shows the timber inventory at the midpoint of each period, before harvest, total volume scheduled for harvest, and the growth. The growth and harvest shown here is the total for each five-year period. Inventory is split into two components – the inventory on timberland actively managed and the inventory on timberland that is not actively managed.

- Revenues and Costs – shows the total stumpage revenue, DNRC's management costs and the net revenues each period. The PNV is the present net value calculated using a 4% discount rate.

- Acres Harvested by Harvest Type – shows the annual acres scheduled for harvest each period. Existing stands are the stands that currently exist out in the forest. Regen stands are stands that were final harvested sometime during the planning horizon. For the most part, the "partial cuts" shown here are the periodic harvests scheduled as part of the uneven-aged regimes. Partial cuts, however, may come from commercial thins in even-aged management regimes. All of the partial cuts on the regen stands are commercial thins in the even-aged regimes.

4.2.1 Benchmark Runs

A number of early benchmark runs were designed to establish that the model was properly constructed and to observe how the model would behave under different kinds of constraints. While an important part of the model building process, these early runs provide little useful information for policy analysis, and are not discussed here.

4.2.2 BM001 – Maximum Biological Potential

Run BM001 establishes the maximum sustainable biological potential – the highest sustainable harvest level possible. In this run, all commercial forested acres are managed under regimes that result in a total harvest schedule that maximizes present net value.

Under Run BM001, the sustainable harvest level is 94.6 MMbf/year from 668,168 acres. Using a 4% discount rate, the PNV is $346 million.

This run is constrained only by the non-declining yield constraints. It shows a sustainable harvest level that maximizes the present value of the revenues flowing to the trusts. The results of this run also provide insight into revenue maximizing management strategies. Nearly all acres, for example, are managed under even-aged management regimes with rotation ages 80 years and older.

4.2.3 BM002 – Operable Acres, Snag and Snag Recruit Retention

Run BM002 establishes the potential from the operable acres, given the snag and snag recruit retention policy, and a non-declining yield constraint. For this run, over 89,000 acres identified in the SLI as "deferred" were withdrawn from the operable timber base. The snag and snag recruit retention policy is modeled by reducing total harvest volume by 1.5 Mbf/acre on moist types and 0.5 Mbf/acre on the dry types.[18]

Under Run BM002, the sustainable harvest level is 79.9 MMbf/year from 578,471 acres. Using a 4% discount rate, the PNV is $268.0 million. Most of the harvest would come from even-aged systems.

Volume left behind as snags or snag recruits is proportional to the number of acres with a final harvest. Runs with more even-aged management leave behind more volume in snags and snag recruits. In this run, the average snag and snag recruit volume was about 6 MMbf per year. Runs with fewer even-aged acres and with longer rotations have less volume in leave trees.

4.2.4 BM003 – Relax the Harvest Constraints

BM003 sets an annual harvest floor of 79.9 MMbf, but allows harvest to rise above that, even though the harvest may not be sustainable. All other constraints are the same as BM002.

Under this formulation, the model scheduled 110.5 MMbf for harvest annually during the first period. Harvest then fell back to the 79.9 MMbf floor.

BM003 identifies an opportunity to harvest above the sustainable level, without falling below the sustainable level. Essentially, there is inventory excess to that needed to sustain a harvest of 79.9 MMbf.

4.2.5 SYC001- Riparian Constraints

Run SYC001 assigns riparian acres to regimes compatible with riparian management objectives. For this run, 11,900 acres were assigned to riparian regimes appropriate when fish are present, and 15,170 acres were assigned to riparian regimes appropriate when fish are absent. All of the constraints from BM002 were applied to this run.

Under Run SYC001, the sustainable harvest level drops to 78.0 MMbf/year from 577,338 acres. Using a 4% discount rate, the PNV is $257.6 million – a reduction of $10.4 million, or 3.9% from BM002.

4.2.6 SYC002 – Grizzly Bear Core and Buffer Areas

Run SYC002 assigns 48,904 acres in the established Grizzly Bear core and buffer areas to compatible regimes – the no harvest regime. These acres overlap to some extent with the

[18] Moist types are WL, WP, and MC; dry types are PP and DF; cool types are LPP and AF.

deferred acres and the riparian acres, so the impact is somewhat less than might be expected. All of the constraints from SYC001 were applied.

Under Run SYC002, the sustainable harvest level drops to 73.2 MMbf/year from 536,730 acres. Using a 4% discount rate, the PNV is $232.7 million – a reduction of $24.9 million or 9.7% from the previous run. PNV reductions are disproportional due to high value stands in grizzly bear core being removed from solution. The drop in managed acres does not equal actual acres in core due to overlap with other deferrals and the incremental aspect of adding constraints.

4.2.7 SYC003 – Sensitive Watersheds

Run SYC003 limits the amount of even-aged final harvest in watersheds designated as "sensitive." No more than 25% of the acres in a sensitive watershed may be less than 40 years old at any point in time.[19] Nearly 111,000 acres are in these watersheds, meaning that no more than 27,741 acres can be less than 40 years old at any point in time. This constraint is applied to watersheds within certain "Level 1" areas (SW Land Office, Stillwater, Swan and other Northwest Land Office units). All of the constraints from SYC002 were applied.

Under Run SYC003, the sustainable harvest level drops to 72.8 MMbf/year from 536,730 acres. Using a 4% discount rate, the PNV is $230.9 million – a reduction of $1.8 million or 0.8% from the previous run. Note that this run does not remove any acres from the managed base, it simply extends the rotation and/or reassigns acres to uneven-aged management, within the high risk watersheds.

4.2.8 SYC004 – Eagle Habitat

Run SYC004 assigns 1,050 acres in "eagle nest areas" and 8,450 acres in "eagle primary use areas" to management regimes compatible with those objectives. All of the constraints from SYC003 were applied.

Under run SYC004, the sustainable harvest level drops to 72.4 MMbf from 536,280 acres. Using a 4% discount rate, the PNV is $228.9 million – a reduction of $2.0 million or 0.9% from the previous run.

4.2.9 SYC005 – Grizzly Bear Visual Buffers

Run SYC005 assigns 3,800 acres in the Grizzly Bear visual buffers to compatible regimes. These visual buffers are acres managed to provide visual screening from open roads that are not already part of the Grizzly Bear core or buffer areas addressed in SYC002. This regime effectively eliminates even-aged management regimes from the visual buffers. All of the constraints from SYC004 were applied.

Under run SYC005, the sustainable harvest level drops to 72.1 MMbf from 535,866 acres. Using a 4% discount rate, the PNV is $227.2 million – a reduction of $1.7 million or 0.7% from the previous run.

[19] The 25% constraint is more restrictive than the standard described in Appendix F.

4.2.10 SYC006 – Old Growth Constraints

Run SYC006 contains a number of constraints designed to meet biodiversity objectives. The constraints are based on the old growth definitions offered by Green et.al. (1992) which consider an acre as old growth when there are a minimum number of trees per acre of a given size *and* a given age, as shown in **Table 4.2**.[20]

Table 4.2
Green et. al. (1992) Old Growth Definitions
as Adapted for the Forest Management Model

Westside

POTVEG	Minimum Age	Trees per acre	Minimum DBH
WP	180	10	21"
PP	170	8	21"
DL	170	10	21"
DF	170	8	21"
LP	140	10	13"
MC	180	10	21"
AF	180	10	17"

Eastside

POTVEG	Minimum Age	Trees per acre	Minimum DBH
PP	180	4	17"
DF	200	5	17"
LP	150	12	10"
SF	160	7	17"

From an inventory and modeling standpoint, the minimum age requirement found in the Green et.al. (1992) old-growth definitions present a challenge. Tree age is an expensive piece of data to collect and is sampled infrequently, if at all. Tree ages in the USFS FIA data, furthermore, appear to have been capped at age 200 for large trees. Tree ages for trees that were not bored are typically estimated based on diameter/age relationships from the sampled trees. These relationships are typically not very strong.

The SLI identifies stands expected to meet old growth definitions. In total, about 80,900 acres are identified as currently being old growth – about 11% of the total forest land.

Given concerns about the reliability of tree ages, old growth constraints in the model are considered in two parts. During the first 100 years of the planning horizon, the model is

[20] Green, P., J. Joy, D. Sirucek, W. Hann, A. Zack, and B. Naumann, 1992, *Old-growth forest types of the Northern Region*, USDA Forest Service, Northern Region, internal manuscript, 60p.

constrained to manage at least 75% of the stands in the moist and dry types currently identified as old growth under the old growth compatible uneven-aged management regimes. The remaining acres were available for treatment using any regimes. There are no old growth specific regimes for stands currently identified as old growth in the cool types because of the stand-replacement nature of disturbance at these sites.

Final harvest of the stands currently identified as old growth in the dry and moist types is limited to 1.25% of the total per five year period for the first 20 periods. Final harvest for stands currently identified as old growth in the cool types is limited to 2.5% of the total per five year period for the first 20 periods. These constraints are applied by Level 1 area and by Potential Vegetation class.

After 100 years, the model was required to show that there are a minimum of 55,700 acres meeting the Green et.al. (1992) old growth definitions. These constraints could be met from the acres currently identified as old growth, or from acres that grow into the old growth definition. **Table 4.3,** shows a surplus of acres meeting the Green et.al. (1992) definition in year 100 and year 175 of the planning horizon. Some of these acres occur with stands in deferred areas while others are within the managed land base. The numbers should not be viewed as retention commitments or as firm estimates of future old growth amounts due to natural processes continuing to influence the development of stands in deferred areas and other factors.

Table 4.3
Acres Meeting Old Growth Definitions
Period 20 and 35

	SYC006v2		SYC008v4		SYC009v2	
	Per 20	Per 35	Per 20	Per 35	Per 20	Per 35
AF	18,414	22,286	19,407	22,373	18,813	22,456
DF	10,342	16,044	21,067	30,568	14,753	22,624
MC	5,947	7,124	6,200	7,721	5,926	7,721
PP	11,367	29,775	35,494	73,436	33,717	72,438
WL	16,423	24,872	18,161	39,298	16,434	40,155
WP	3,278	4,222	4,052	4,473	3,306	4,410
Total	65,771	104,323	104,381	177,869	92,949	169,804

Under run SYC006, the sustainable harvest level drops to 71.0 MMbf from 532,697 acres. Using a 4% discount rate, the PNV is $219.6 million – a reduction of $7.6 million or 3.3% from the previous run.

4.2.11 SYC007 – 1996 Forest Plan Constraints

The desired future condition (DFC) described in the 1996 SLFMP focuses on moving the forest toward a greater representation of shade-tolerant tree species such as Ponderosa Pine, Western Larch and Western White Pine, or earlier seral stages. This coarse-filter objective was built into the management regimes. Even-aged management regimes establish a new stand with a species mix appropriate to the PotVeg class. For example, when an existing stand with a PotVeg class of Ponderosa Pine is regenerated, the new stand is heavy to Ponderosa Pine seedlings, and any intermediate treatments favor retention of the Ponderosa Pine. Similarly, the uneven-aged regimes favor the species appropriate given the PotVeg class. At each entry into a stand where PotVeg is Ponderosa Pine, for example, Pine is favored for retention.

The 1996 SFLMP (Appendixes, page SCN-20, Table T-2) also specifies that 40% of the forest would be managed under even-aged systems.[21] The model was constrained to limit the number of acres that could be assigned to even-aged management regimes by Level 1 area and by PotVeg group, as shown in **Table 4.4.** These percentages were applied to the acres designated as "managed" under run SYC006.

Table 4.4
Percent of acres available for even-aged management regimes

	Central	Eastern	NW Other	Stillwater	Southwest	Swan	Total
Dry	30%	30%	30%	30%	35%	30%	32%
Moist	50%	50%	50%	50%	50%	50%	50%
Cool	90%	90%	80%	80%	80%	80%	82%

Under run SYC007, the sustainable harvest level drops to 56.5 MMbf from 448,788 acres. Using a 4% discount rate, the PNV is $158 million – a reduction of $61.6 million or 28.1% from the previous run.

Adding the 1996 SFLMP constraints results in a substantial decrease in harvest potential for two reasons. First, the uneven-aged management regimes are less productive than the even-aged regimes. Under SYC007, annual harvest averages 126 board feet per managed acre per year, substantially less than the 139 board feet per managed acre per year from BM002, which used even-aged regimes almost exclusively.

Second, a subtle interaction between the Forest Plan constraints and the non-declining yield constraint reduce the total number of acres assigned to active management regimes. **Appendix E** explains that interaction more completely through a simplified example.

4.2.12 SYC008 – Implementation Constraints

A set of constraints were added to SYC007 to ensure that the harvest schedule could be reasonably implemented. These constraints are based on close inspection of SYC007 and DNRC's best judgment about how to make the harvest schedule workable. The implementation constraints are:

- Total harvest in the first five periods is limited to 11,000 acres per year. This approximates the maximum acres prepared for sale in any year since 1996.
- Even-aged final harvests in the first five periods are limited to 4,700 acres per year. This approximates the even-aged harvest amounts identified in the SFLMP.
- Uneven-aged harvests in periods 7 through 12 are limited to 5,300 acres per year.

[21] Even-aged harvest systems are those that employ a final harvest – either clearcut, shelterwood or seed tree harvest.

- Minimum annual harvest levels were set for each Level 1 area. The minimum annual levels were based on 50% of the average LO harvest from the previous run:
    - Central LO: 2.0 MMbf
    - Eastern LOs: 1.2 MMbf
    - Stillwater: 5.2 MMbf
    - Swan: 3.0 MMbf
    - Other NW LO: 8.4 MMbf
    - Southwest LO: 7.6 MMbf

Under run SYC008, the sustainable harvest level drops to 53.2 MMbf from 430,784 acres. Using a 4% discount rate, the PNV is $146.1million – a reduction of $11.9 million or 7.5% from the previous run.

Table 4.5 shows the annual average harvest by land office over the 175 year planning horizon. **Appendix A** shows that these constraints did smooth the acres harvested between periods.

Table 4.5
Average Annual Sustainable Harvest: SYC008
(MMbf Sawtimber).

Land Office	Average Annual Harvest
Eastern offices	2.5
Central	3.9
Southwest	13.6
Northwest	33.2

A sensitivity analysis was performed to determine how flexible the model solution is with respect to the harvest in the first two periods. A model run was formulated to make unavailable for harvest in periods 1 and 2 half of the acres in each AU scheduled for harvest in period 1 and 2 under SYC008. This new run had a harvest level 1.5% less (0.8 MMbf) and a PNV 3.5% less ($5.1 million) than SYC008. This suggests that there is a great deal of flexibility in implementing the harvest schedule.

4.2.13 SYC009 – Relaxed Flow Constraints

BM003 and other runs identified a substantial surplus of inventory volume in the short run. SYC009 has all of the constraints from SYC008 but allows harvest to fluctuate 10% around the SYC008 average harvest of 53.2 MMbf.

As shown in **Appendix A**, harvests under SYC009 are at the 10% ceiling for the first 18 periods, and then fall to the 10% floor until period 30. After that, harvest levels fluctuate around the 53.2 MMbf level. Over the 175 year planning horizon, SYC009 harvests 40 MMbf more than SYC008. The Long Term Sustained yield calculation for the two runs is identical.

The PNV for SYC009 is $163.6 million – a $ 17.5million or 12% increase over SYC008. This increase is due to the fact that more timber is harvested earlier in the planning horizon.

SYC009 harvests more acres sooner in the schedule, and moves toward the desired future condition at a rate similar to SYC008.

4.2.14 SYC010 – Harvest Floor Equal to SYC008

This is another run designed to explore opportunities to use the surplus inventory in the short run. SYC010 has all of the constraints from SYC008 but allows harvest to increase 10% above, but never fall below the 53.2 MMbf annual harvest of SYC008.

As shown in **Appendix A**, harvests under SYC010 are at the 10% ceiling for the first 70 years, and then fall back to the 53.2 MMbf harvest floor. Over the 175 year planning horizon, SYC010 harvests about 350 MMbf more than SYC008. The Long Term Sustained yield calculation for the two runs is identical. (The Long Term Sustained Yield is a calculation of the level of harvest that could be sustained after the 175-year planning horizon.)

The PNV for SYC010 is $163.5 million – a $ 17.4 million or 12% increase over SYC008. This increase is due to the fact that more timber is harvested earlier in the planning horizon.

SYC010 harvests more acres sooner in the schedule, and moves toward the desired future condition at a rate similar to SYC008.

4.2.15 Management Restrictions not included in the Model

The Forest Management Model reflects administrative rules and management direction that limit the number of acres managed, allocate certain acres to specific management regimes, regulate how much management can be done, and regulate the flow of outputs or inputs.

This is not an appropriate model for examining certain kinds of management standards and guidelines, however. Seasonal use restrictions, road construction standards, sale design parameters, etc. are examples of management guidelines that do not lend themselves to this kind of modeling.

For this reason, there are some provisions of the 2003 administrative rules that are not considered in this report. We believe, however, that we have incorporated all of the rules that would affect the calculation of the sustainable yield. **Appendix F** has more details.

4.2.16 Management Advice

The primary objective of the Forest Management Model is to make a sustained yield calculation. Advice about preferred management strategies can be gleaned from the model, however. A few observations are briefly summarized here.

- Stocking control should be a primary management objective. On even-aged acres, priority for harvest should be acres with low stocking. On the less constrained runs, the model worked hard to regenerate first the lower stocked acres, establishing a more properly stocked forest. Precommercial thinning is a major activity required to achieve the yields calculated by the model.

- On acres assigned to uneven-aged management, cut the more heavily stocked acres first. Reduce stocking to desired levels early in the schedule.

- In general, even-aged management is more productive and more profitable. To the extent possible, the model assigns the more productive acres to even-aged management regimes.

- There is more inventory than is needed to sustain probable harvest levels. This excess inventory could be used to increase revenues, and/or may be used to provide certain habitat conditions.

4.3 Comparison of Managed Acres

Figure 4-1 compares the acres actively managed under each model run. For this graph, "managed acres" means acres that are scheduled for at least one commercial harvest sometime during the 175 planning horizon.

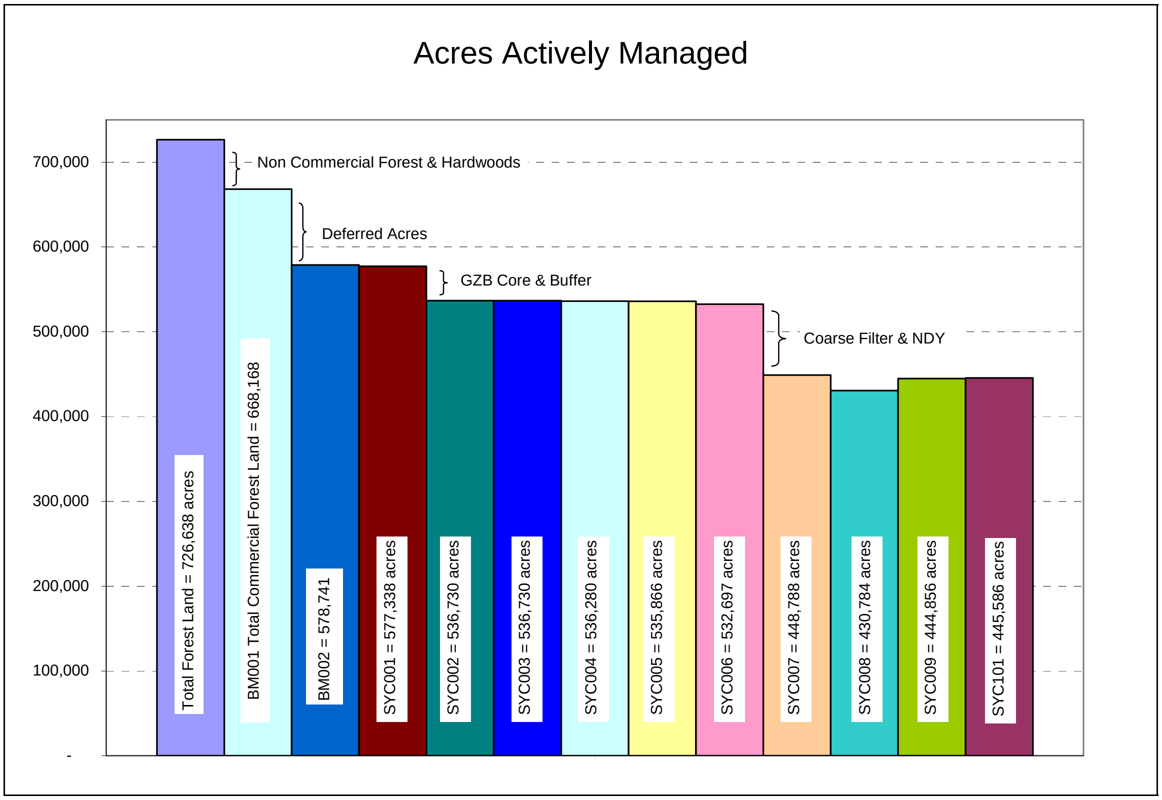


Figure 4-1

There are 726,638 forested acres in the planning model, as shown in the first bar. About 58,470 acres are non-commercial forest land (acres incapable of growing commercial crops of wood fiber) or are hardwood types not considered for commercial harvest. Subtracting these acres leaves 668,168 acres of commercial forest land. This is the operable land base that forms the basis for BM001.

About 89,000 acres of commercial forest land are identified in the SLI as "deferred." These are acres where there are other land uses (leased cabin sites, campgrounds, municipal watersheds, other designated recreational uses), topography that precludes harvest (cliffs or rock outcrops intermingled with the trees, long slopes >= 80%), wet areas (high water table or standing water), inaccessible parcels or stands with low values combined with relatively high development costs. Subtracting these acres leaves 578,741acres available for harvest in BM002. This is the operable land base.

There are no further specific reductions in operable acres until SYC002, which withdraws from active timber management 48,900 acres in Grizzly Bear Core and Buffer areas. There is some overlap between these and other previously withdrawn acres, so the operable land base falls to 536,730 acres.

The constraints added for SYC003 through SYC006 have little impact on the total operable acres. The next big drop comes from adding the SFLMP constraints in SYC007 – the operable land base becomes 448,788 acres. Heavy reliance on uneven-aged regimes, coupled with the non-declining yield constraint forces some acres out of active management. This phenomenon is explained in **Appendix E**.

For similar reasons, the implementation constraints in SYC008 force another 18,000 acres out of active management. Releasing the non-declining flow constraints in SYC009 allows more acres to come back into production. There are 454,367 acres in the operable base for that alternative.

4.4 Comparison of Sustainable Harvest Levels

BM001 establishes the maximum sustainable biological yield of 94.6 Mbf. This is based on actively managing the entire commercial forest land base under the optimal set of management regimes. As shown in **Figure 4-2**, there are substantial differences between the various model runs. Note, however, that the y-axis in **Figure 4-2** has been scaled to illustrate the differences between the runs. Just as with the discussion of acres actively managed the annual harvest effects of adding in new constraints displays the incremental effect of the new constraint given all the others previously incorporated. The order of entry can affect the apparent consequences of the constraints.

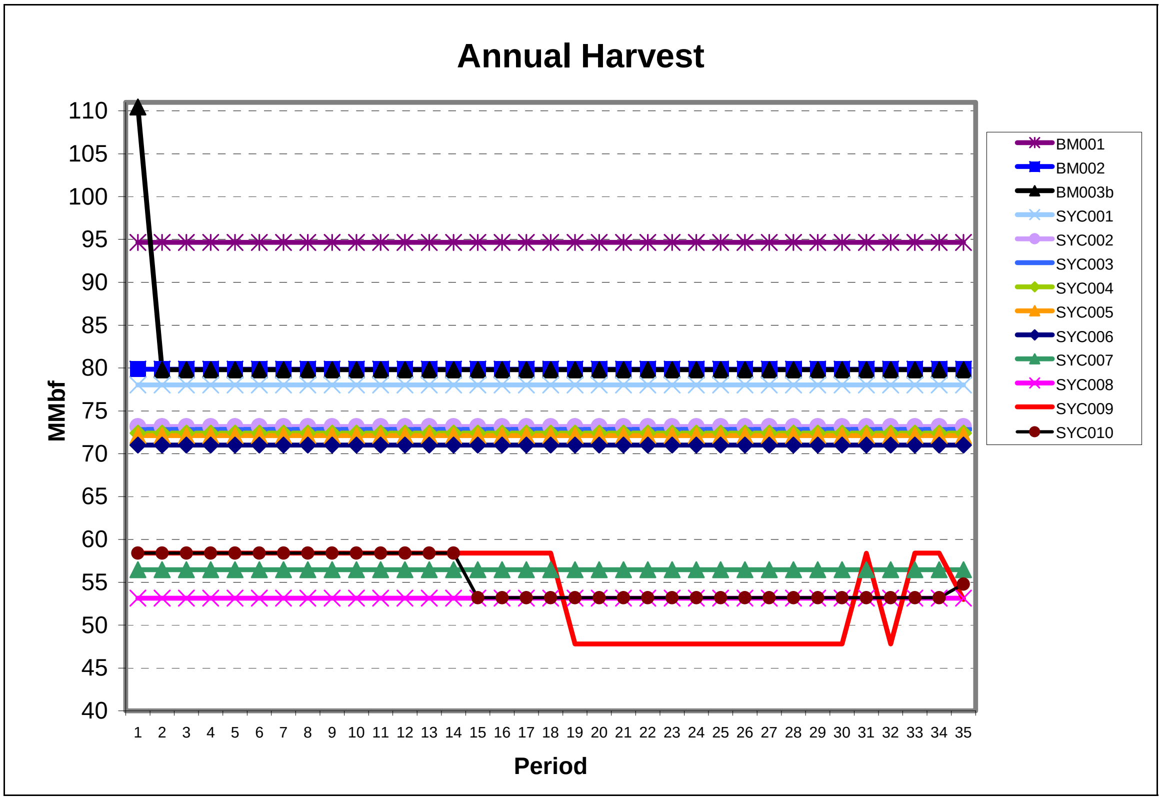


Figure 4-2

Taking the deferred acres out of production, and accounting for leave trees on final harvest acres drops the sustainable yield down to 79.9 MMbf for BM002. BM003 allows a departure from the non-declining flow constraints. Under this run, 110.5 MMbf could be harvested each of the first five years, without allowing the harvest schedule to ever fall below the 79.9 MMbf from BM002. This is a measure of the surplus volume in the existing inventory.

The reduction for riparian management is relatively minor – just 1.9 MMbf. The next big drop in sustainable harvest levels is from withdrawing the Grizzly Bear Core and Buffer areas – harvest drops to 73.2 MMbf. Constraints for the next several runs make minor reductions, primarily due to allocations to more uneven-aged management regimes.

The next big drop is for the 1996 SFLMP constraints incorporated into SYC007 – down to 56.5 MMbf. The implementation constraints in run SYC008 would reduce harvests another 3.3 MMbf for a final calculation of 53.2 MMbf.

Run SYC009 relaxes the harvest flow constraints – allowing harvests to fluctuate 10% around the 53.2 MMbf harvest level of SYC008. To maximize PNV, the model harvests more volume sooner in the schedule, dropping the harvest level to the lower bound in period 21.

4.5 Comparison of Inventory Levels

Figure 4-3 compares the inventory on the acres actively managed under each alternative. There are two things to note here. First, the beginning inventory on the managed acres is directly related to the number of acres actively managed. BM001 has the highest inventory in Period 1, SYC008 has the lowest.

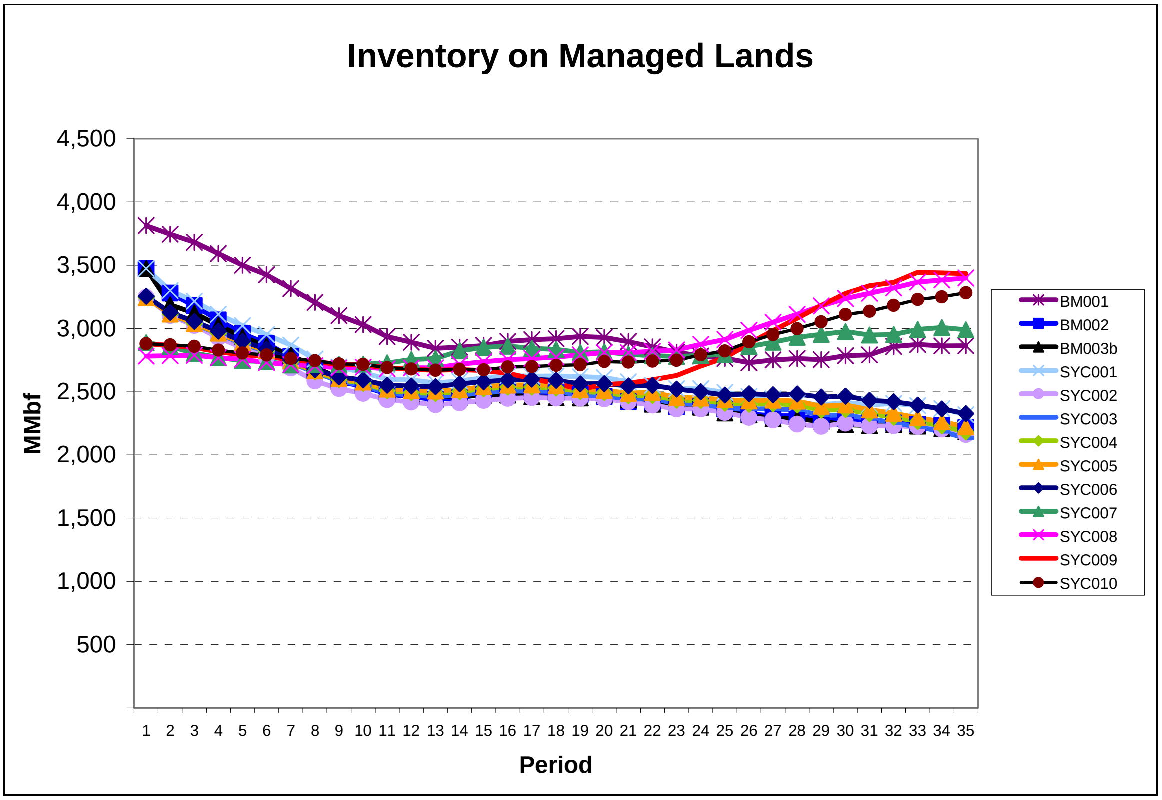


Figure 4-3

Second, in model runs that prescribe primarily even-aged management, the managed inventory decreases over time. Many of the existing acres carry more stocking than is needed in a regulated, properly stocked forest. Under BM001, for example, the inventory falls about 25% by period 13, and then levels off around 2.8 Bbf.

Conversely, runs that rely more heavily on uneven-aged regimes have generally increasing inventories. Some of the uneven-aged regimes require a high stocking level before harvest is permitted. After an initial stocking adjustment, other uneven-aged regimes carry more normal stocking levels, but on average carry more stocking than the even-aged regimes.

The inventory graphs in **Appendix A** show the inventory projection for both the managed and unmanaged acres. Note here that the inventory on the unmanaged acres continues to increase throughout the 175 year planning horizon. This illustrates the deterministic nature of the projections – while the growth and yield model projections account for competition induced mortality, they do not project episodic mortality from insects, disease or fire. It is unlikely that inventory on the unmanaged stands would actually increase to these levels towards the end of the modeled projection. As stocking levels increase over time, these stands would become more susceptible to increased mortality from insects, disease and fire.

4.6 Comparison of PNV

Figure 4-4 compares the runs in terms of Present Net Value (PNV). The differences in PNV are similar to the differences in managed acres and the differences in volume harvested. The PNV for SYC008 is $146.1 million, just 42% of the $345.9 million for BM001. Accelerating the harvest in SYC009 increases the PNV to $163.6 million.

Again, readers are cautioned that these PNV calculations should not be viewed as appraisal values. And, that the differences from one model run to the next represent the incremental costs of incorporating the new constraint given all the other constraints are already incorporated into the model in previous runs.

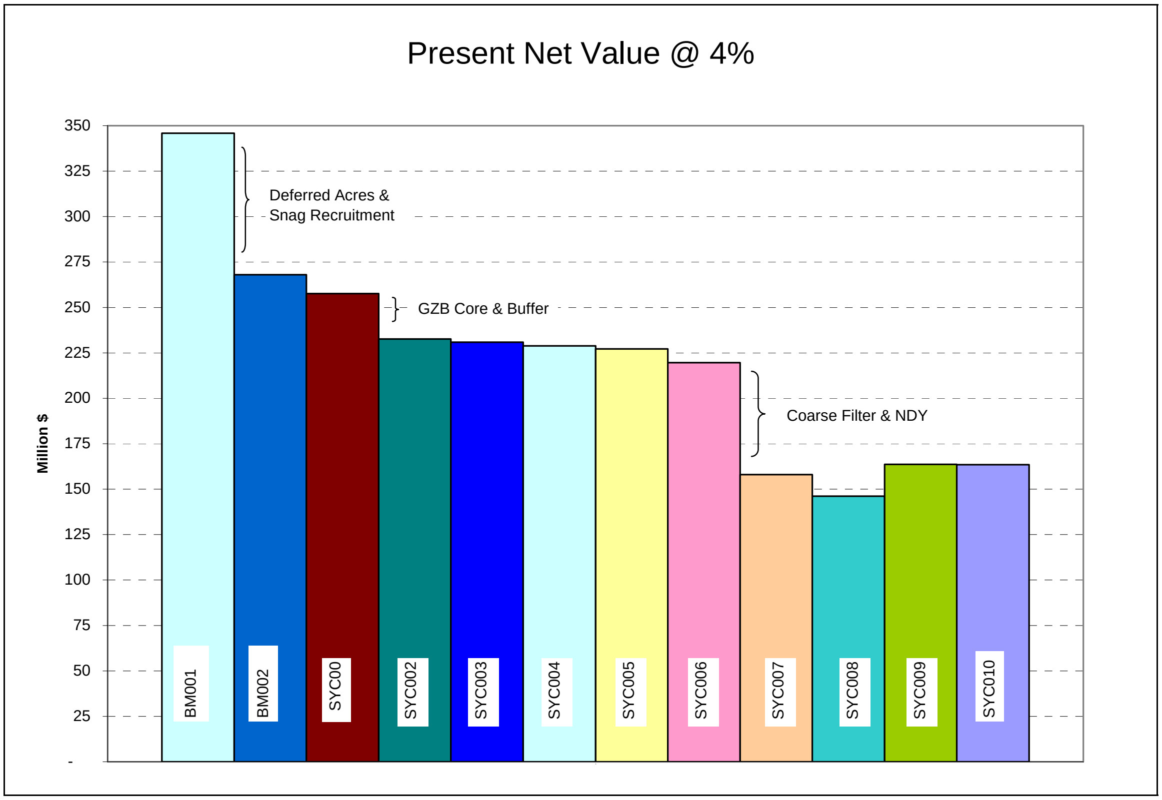


Figure 4-4

4.7 Progress toward the DFC

One of the objectives of the 1996 SFLMP is to move the forest toward earlier seral stages. The earlier seral stages have more stocking in the shade intolerant species and are more resistant to insect, disease and fire.

Figures 4-5 and **4-6** illustrate progress toward the desired future condition established in the 1996 SFLMP under run SYC008. As described above, every stand has a PotVeg type that states the desired species for that stand. The management regimes are designed to promote that desired species mix. The graphs show the percent representation of shade intolerant species (ponderosa pine and western larch) and shade tolerant species in managed versus unmanaged stands. As shown, active management moves the forest in the direction of desired future condition. Lack of active management, on the other hand, does not move the forest toward the desired future condition.

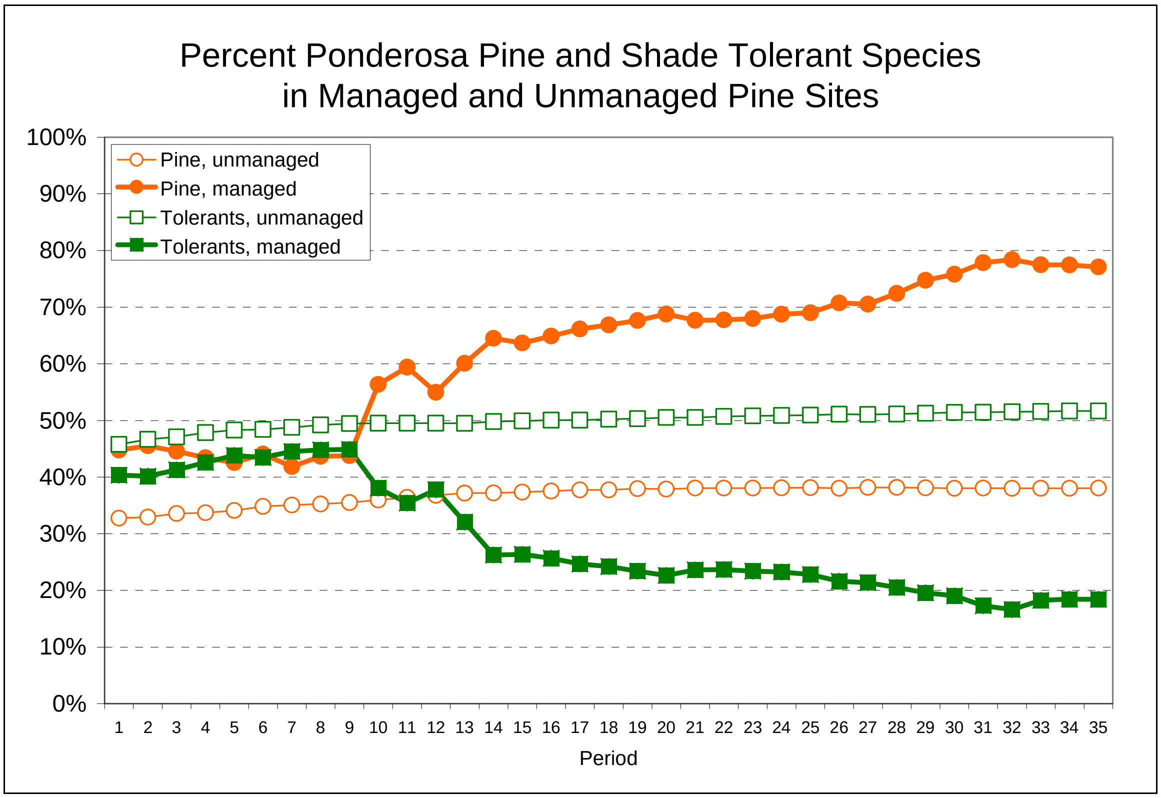


Figure 4-5

In these figures, each line shows the inventory of the target species as a percentage of total inventory on that type. **Figure 4-5**, for example, shows that in period 1, Ponderosa Pine accounts for 45% of the inventory on stands where PotVeg = PP. By period 13, that figure has increased to 60%. Shade tolerant species on Ponderosa Pine sites, meanwhile, decrease from about 40% to about 18% of the total inventory in the managed stands. Shade tolerant species increase in the unmanaged stands. Since there is no harvest on the unmanaged acres, this is a picture of succession rendered by the growth and yield model.

Figure 4-6 shows similar trends on stands where the desired future condition is western larch.

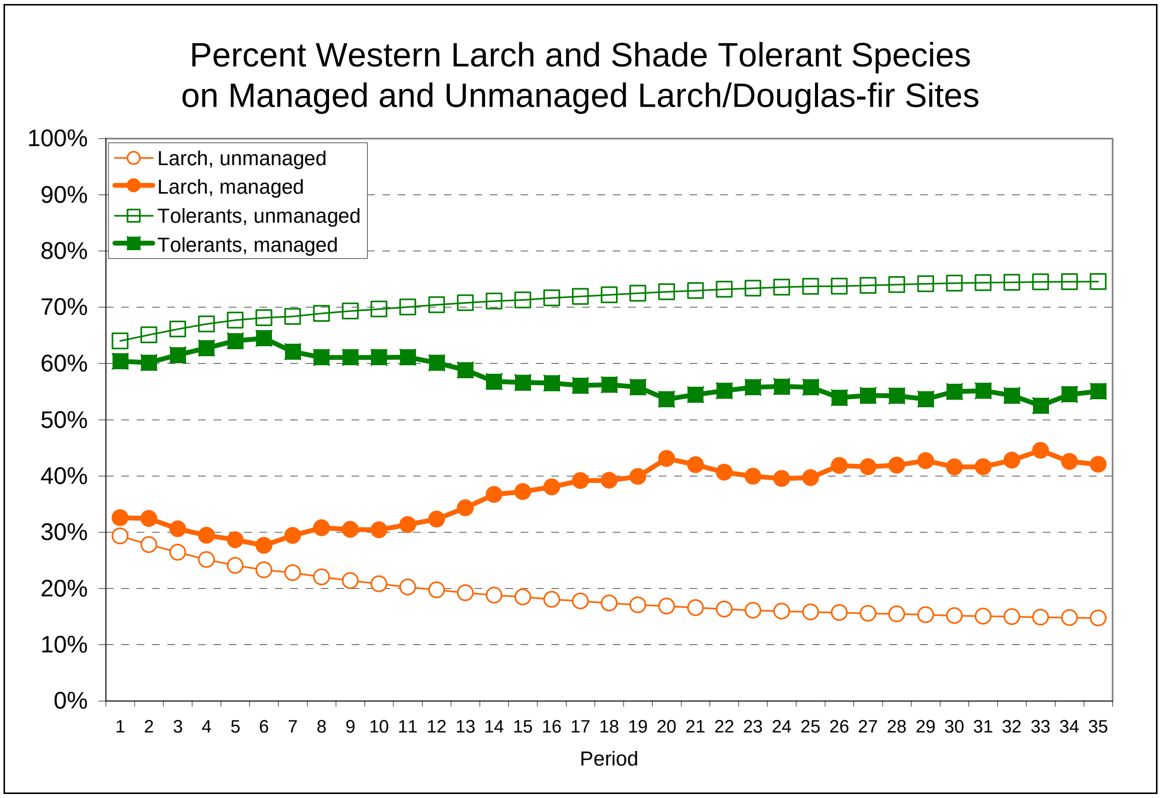


Figure 4-6

4.8 Summary of Findings

Following is a brief summary of findings.

- Management of DNRC timberland under the 1996 SFLMP and the 2003 administrative rules provides for a sustainable harvest level of 53.2 MMbf.

- The biological potential of the forest – the maximum sustainable harvest level – is 95 MMbf. The deferred acres, the Grizzly Bear core and buffer areas, and the 1996 SFLMP direction account for most of the difference between the biological potential and the 53.2 MMbf sustainable harvest.

- There is excess inventory on the forest. Harvest in the short run could be increased without affecting the long term capability to provide revenues to the trust beneficiaries.

- Even-aged management yields more attractive returns than does uneven-aged management.

- Management should focus on stocking problems. On acres to be managed under even-aged systems, priority should be given to regenerating poorly stocked acres first. On acres to be managed under uneven-aged systems, priority should be given to the overstocked acres.

5 Recommendations for Future Calculations

This sustainable yield calculation utilized the best methods available given time and budget constraints. Several improvements were made from the previous calculation, and we expect that the next calculation will incorporate additional improvements over this effort.

As with any effort of this magnitude, we can suggest a few areas where additional efforts should result in an even better product next time:

- Collect more plot data. The DNRC should increase its effort to collect more plot data representative of the stands managed by the DNRC. Ideally, the DNRC's SLI would be linked to a database containing a unique stand table for each timber stand. This goal, however, probably lies outside the DNRC's budget.

- Join the Inland Growth and Yield Cooperative (INGY). This would make available to DNRC growth plot data that could be used to calibrate growth and yield models specifically to Montana. The INGY dues (about $5,000 annually), would be much less expensive and much more timely than if the DNRC established its own set of growth plots.

- Keep the SLI inventory current. This effort made extensive use of the DNRC's SLI. As with any project of this magnitude, heavy use of the data brought to the surface some areas that could be improved. For example, efforts should be made to update the inventory on a periodic basis particularly for untreated stands. Timely updating due to timber harvesting and disturbance is critical for the SLI to reflect actual forest stand conditions.

6 Glossary and Abbreviations

Analysis Unit (AU) - A set of non-contiguous parcels of land, homogenous with respect to factors that affect outputs, costs, revenues, management choices, management opportunities, management

Basal Area - The area, expressed in square feet, of the bole of the trees on an acre at breast height.

Commercial forest land - Timber land capable of growing commercial crops of trees. Land that can grow 20 cubic feet of timber volume per acre per year.

Cruise - To take field measurements of trees in a timber stand. Cruising is a statistical sampling technique.

Deferred land – Timber land not managed for timber production due to other administrative uses, topography and/or other physical factors, accessibility problems, or high development costs relative to timber values.

Diameter at Breast Height (DBH) - A measure of the diameter of a tree at 4.5 feet above ground level (breast height).

DNRC - The Montana Department of Natural Resources and Conservation

Even-aged management - A management regime culminating in a final harvest. Trees in the newly regenerated stand will be of a similar age.

Forest Inventory and Analysis (FIA) - The periodic timber inventory program conducted by the US Forest Service on timberland across all ownerships.

Forest land - Land at least 10 percent stocked by forest trees of any size, including lands that formerly had such tree cover and that will be regenerated naturally or artificially. The minimum area for classification of forest land is one acre. Roadside, streamside, and shelterbelt strips of trees must have a canopy width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas area are classified as forest if they are less than 120 feet wide. Typically the minimum polygon size in DNRC's stand level inventory is five acres. The area within road clearing widths was estimated using a GIS process and subtracted from each forest polygon to determine a forest acreage estimate "net of roads" for the sustained yield calculation.

Forest Management Model - A linear programming model developed to calculate the sustainable yield, given management objectives and constraints.

GIS - Geographic Information System – a computer-based tool used to store, analyze and report spatial data.

Linear Programming - A mathematical technique used to find an optimal solution, given many choices, a defined objective, and constraints that that limit available choices.

Long Term Sustained Yield (LTSY) – A calculation of the sustainable level of harvest after the 175 year planning horizon. The Forest Management Model calculates the LTSY based on the acres actively managed, and the management intensity, management regimes and rotations selected for each analysis unit.

Maximum Biological Potential - The highest level of timber harvest that could be sustained, assuming all commercial timber land is available for harvest, and optimal management regimes could be implemented. This is a measure used to benchmark the productivity of a forest.

Management Regime - A schedule of specific management actions to be applied to a timber stand over time. Management actions may include activities such as planting, natural regeneration, precommercial thinning, commercial thinning, final harvest, partial cutting, etc.

Mbf - Thousand board feet; MMbf – million board feet; Bbf – Billion board feet, all in Scribner measure. These are measures of timber volume. A typical log truck holds 4-5 Mbf.

Non-declining yield (NDY) - A harvest flow that may increase, but not decrease, over time.

Old growth - A timber stand is designated as "old growth" if it meets the old-growth definition found in Green, et.al. (1992) as adopted by the DNRC.

Present Net Value (PNV) - The value of future cash flows, discounted to the present using a discount rate.

Potential Vegetation Class (PotVeg) - The desired species mix for a given polygon.

Site Index - A measure of the productivity of timberland. Expressed in terms of the height of dominant Douglas-fir trees at age 50. A site index of 75, for example, means that 50-year old Douglas-fir trees would be expected to be 75 feet tall.

Stand Inventory System (SIS) - Commercially available software used to compile and summarize inventory plot data.

Stand Level Inventory (SLI) - The DNRC's computer database used to store, manipulate and summarize data about each timber stand.

Stand Projection System (SPS) - An individual tree growth model used to project future timber volumes.

Sustainable yield "…the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth." **(MCA 77-5-221)**

Tarif equations - Equations that the DNRC uses to calculate Scribner board foot volumes for a tree, given the species, height and DBH of the tree.

Timber stand - A tract of forest land relatively homogenous with respect to species mix, size and stocking of tree species. The minimum stand size is five acres.

Timber Type - A code assigned to each timber stand describing the existing species mix, size class and stocking class.

Uneven-aged management – A management regime that does not have a final harvest. The stand will contain trees of two or more age classes. New trees are regenerated under a canopy of older trees.

7 MB&G Certification

I certify that to the best of my knowledge and belief that:

- The statement of facts contained in this report is true and correct.
- The reported analyses, opinions, and conclusions are limited only by the reported assumptions and limiting conditions and reflect my personal, unbiased professional analyses, opinions and conclusions.
- We have no present or prospective interest in the resource that is the subject of this report.
- Engagement in this assignment was not contingent upon developing or reporting predetermined results.
- Compensation for completing this assignment is not contingent upon the development or reporting of a predetermined result or direction in result that favors the cause of the client.
- Significant professional assistance was provided to the persons signing this certification as follows: Ed Coulter, Jessica Burton, Robb Kirkman and Steve Fairweather.

____

Mark L. Rasmussen
Mason, Bruce & Girard, Inc.

8 Appendices

Appendix A: Summary of Model Runs

Appendix B: Compatibility matrix

Appendix C: Acres in the Forest Management Model

Appendix D: Summary of Uneven-Aged Management Regimes

Appendix E: Interaction between the Forest Plan Constraints and the Non-Declining Yield Constraint

Appendix F: Wildlife And Hydrologic Constraints Incorporated into the Forest Management Model

Appendix G: Modeling Old Growth

Appendix H: Sustained Yield Law, Montana Code Annotated

Appendix I: List of Contributors

Appendix J: SYC Public Involvement Process

Appendix K: Response to Comments Most Frequently Raised During the Public Involvement Process

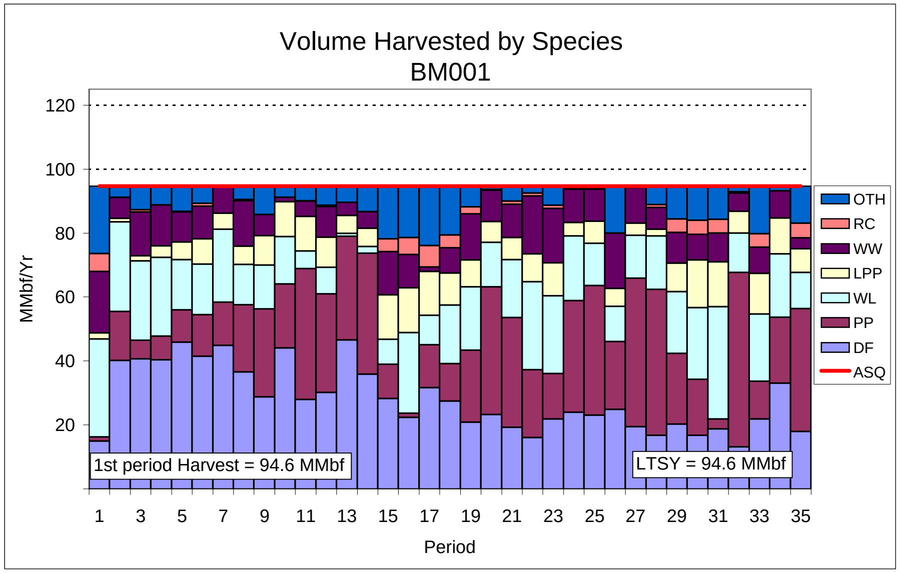
Appendix L: DNRC Forest Inventory

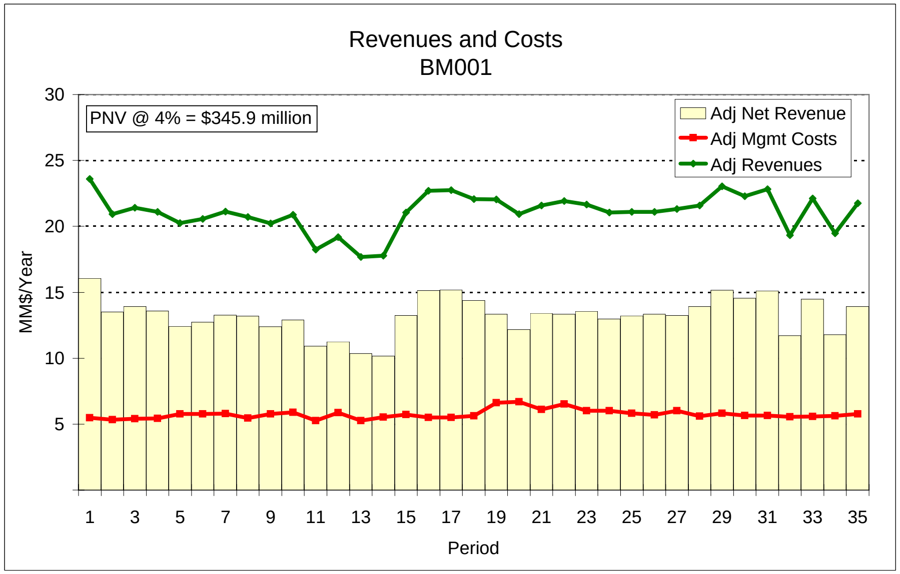
Appendix M: Sample Timber Yield Tables

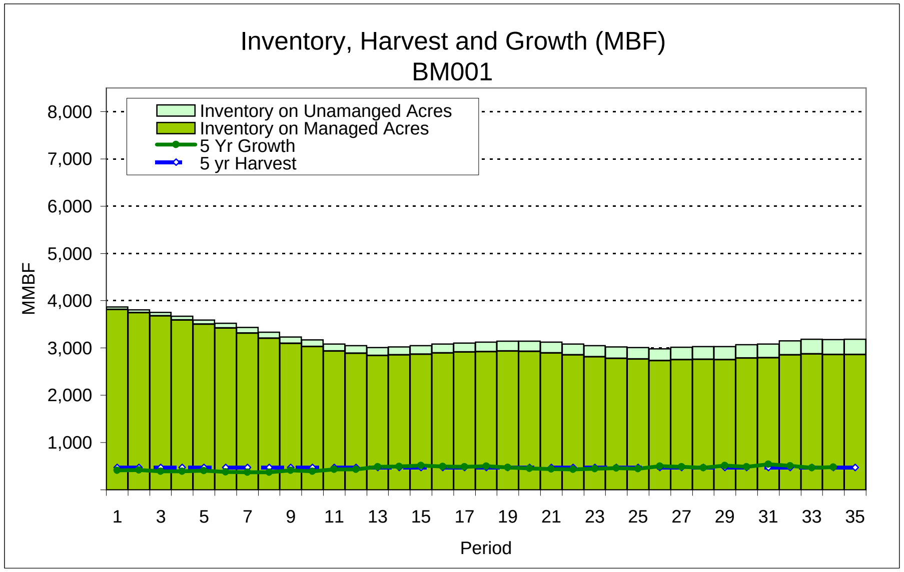
Appendix A

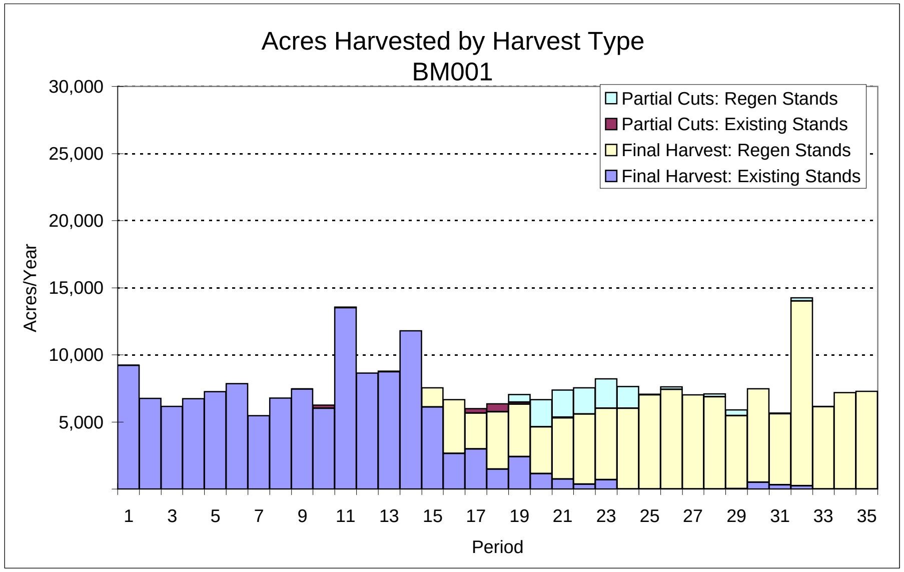
Summary of Model Runs

MT DNRC SYC Calculation
BM001

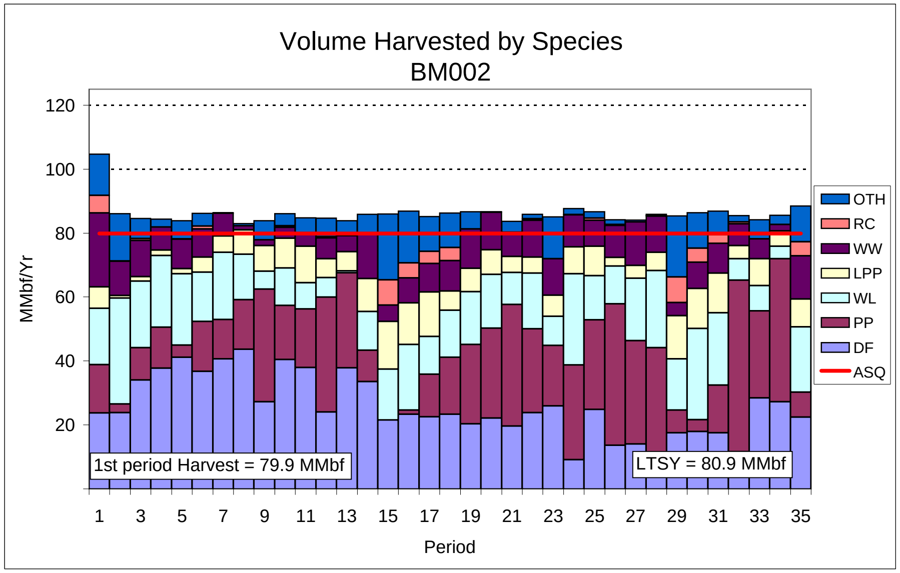


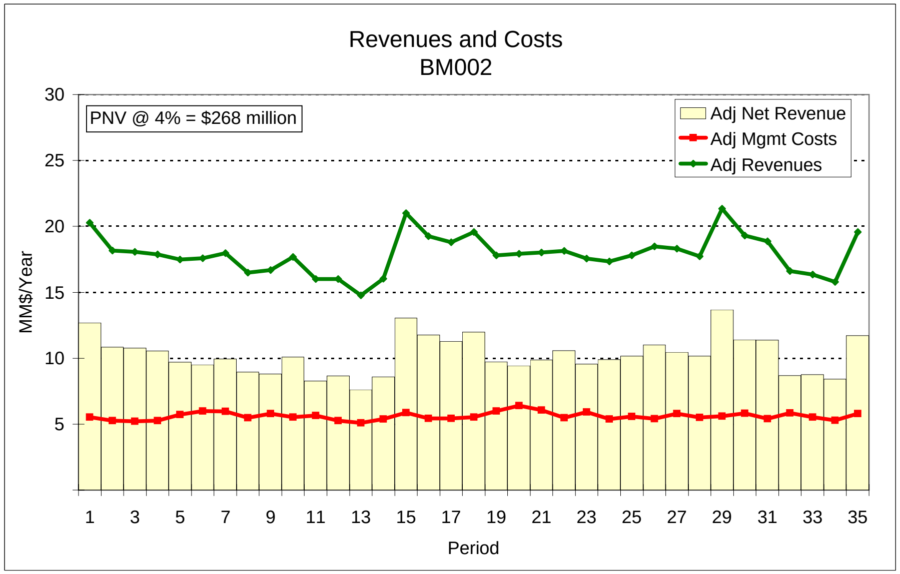


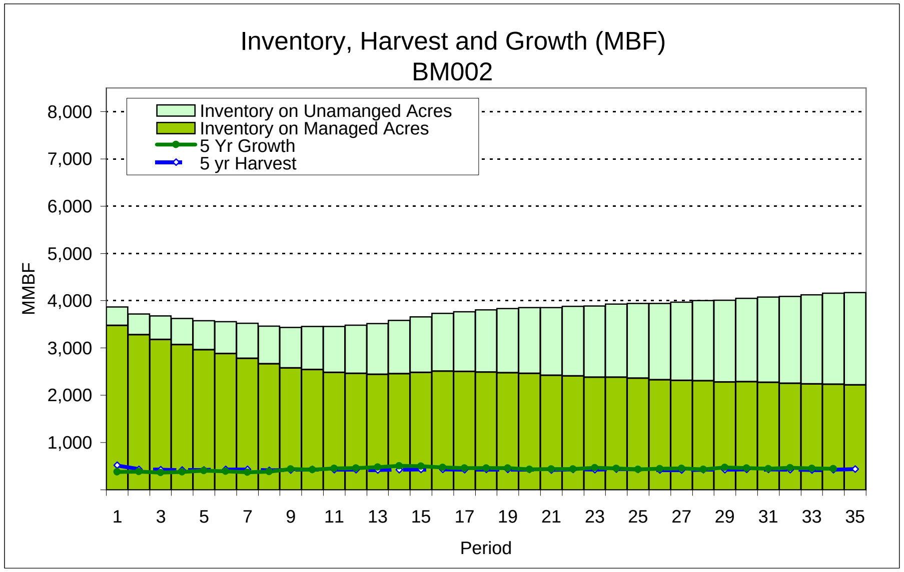


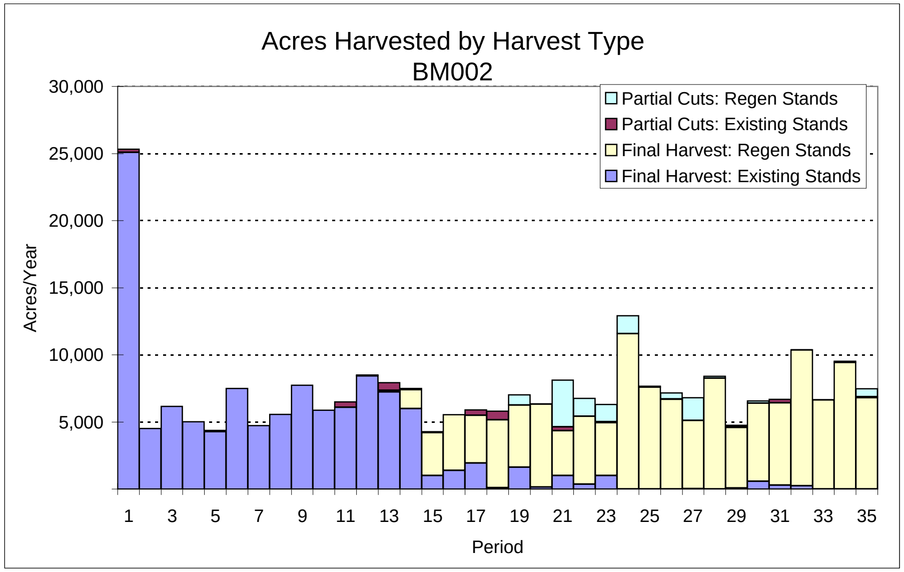


MT DNRC SYC Calculation
BM002









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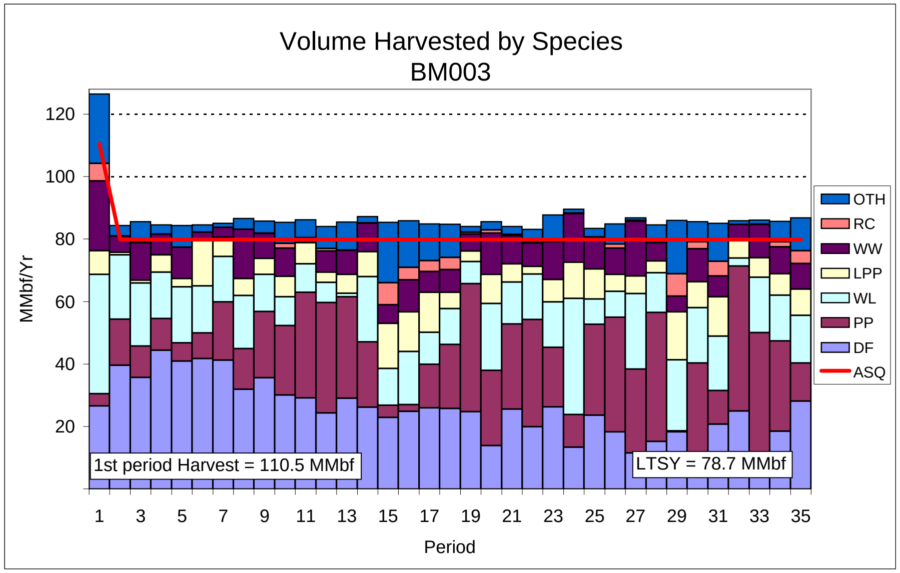
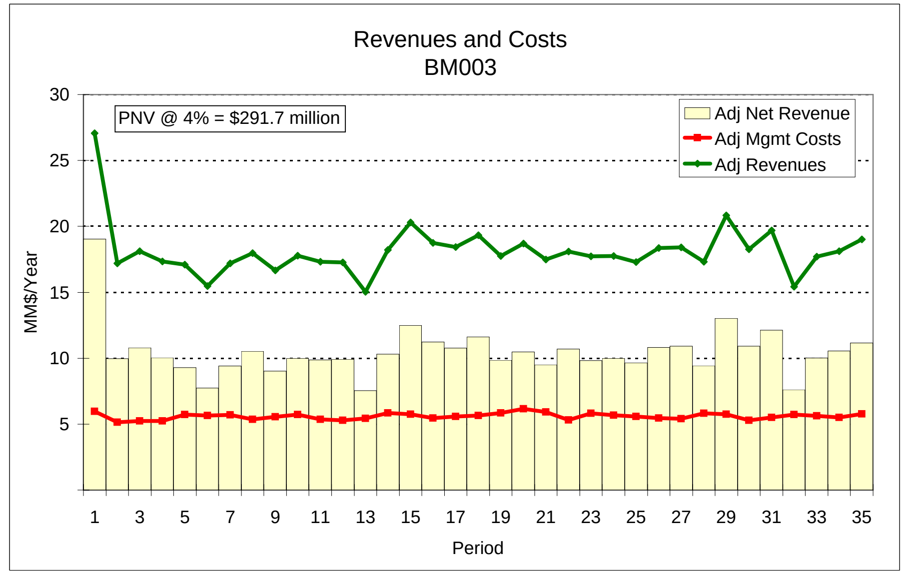
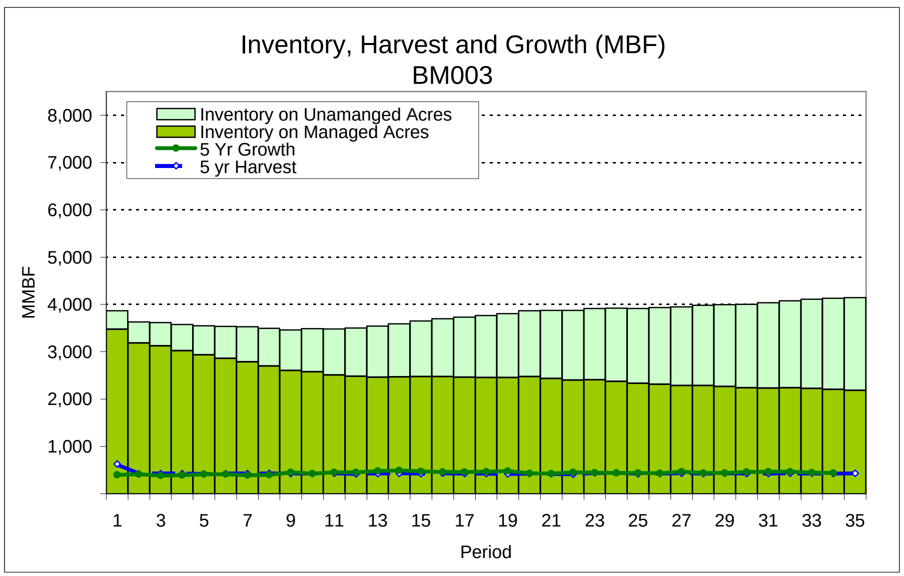
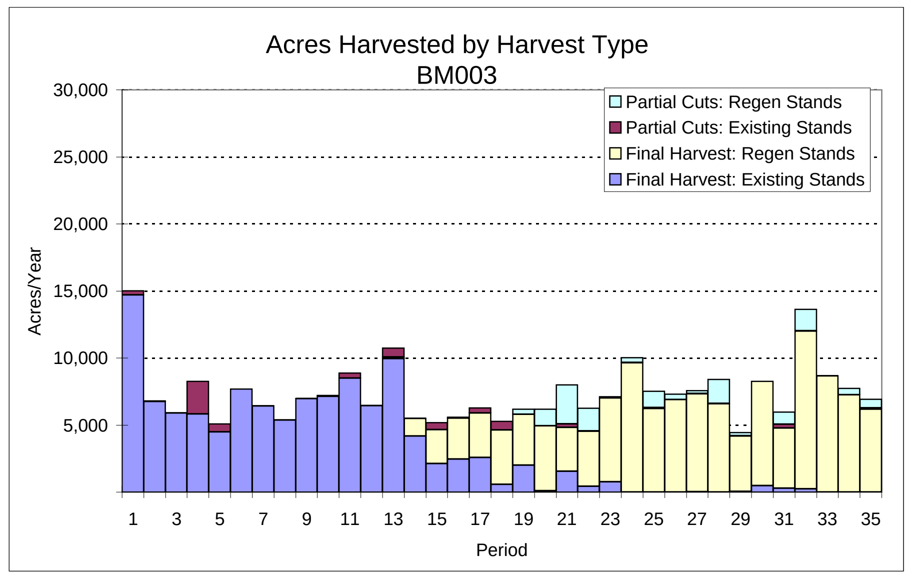
BM003









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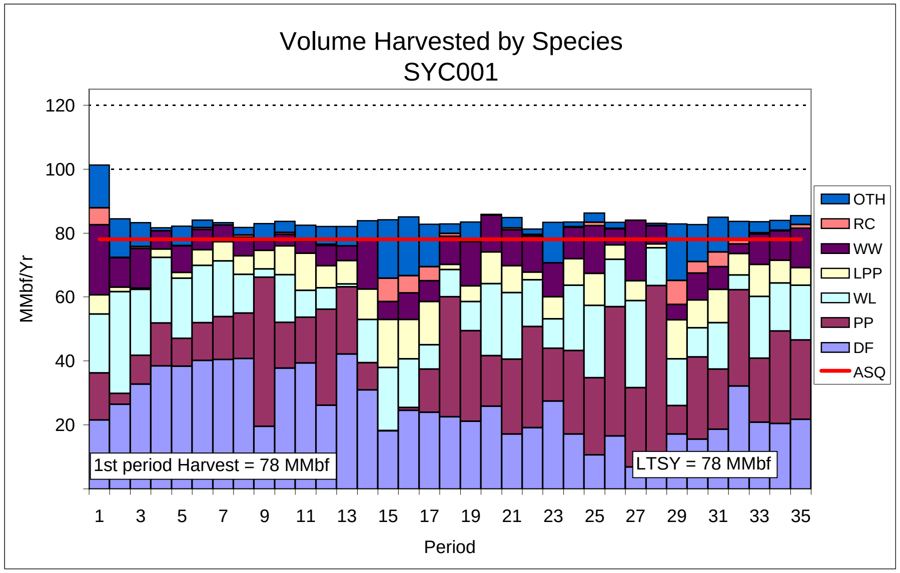
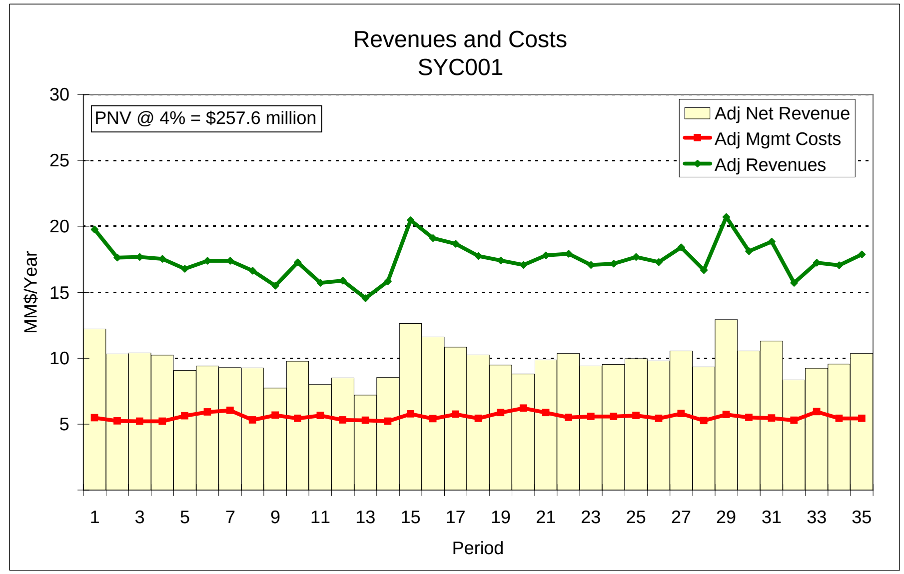
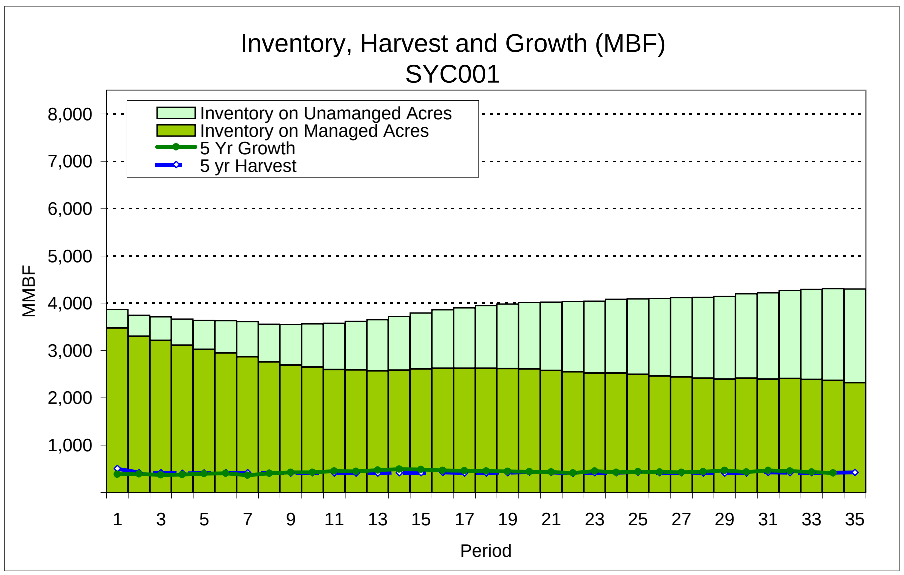
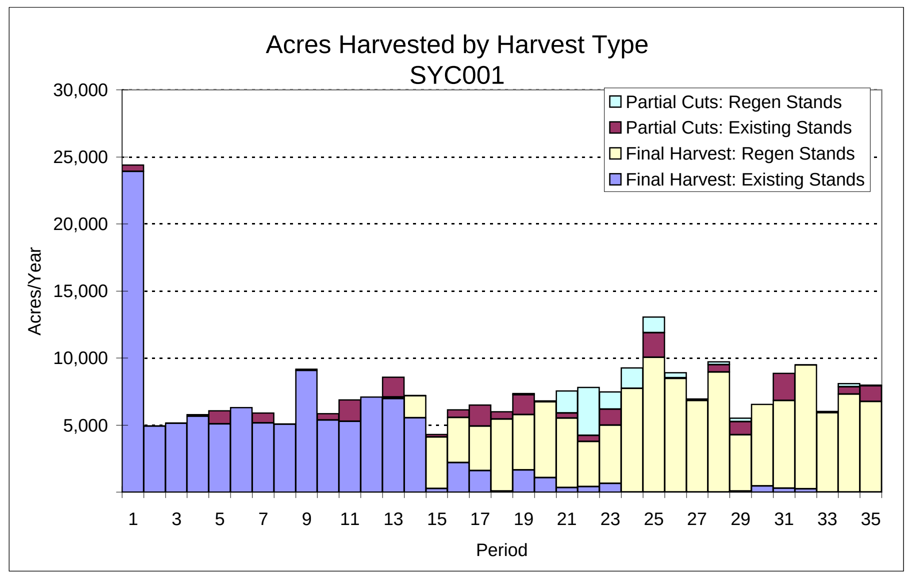
SYC001









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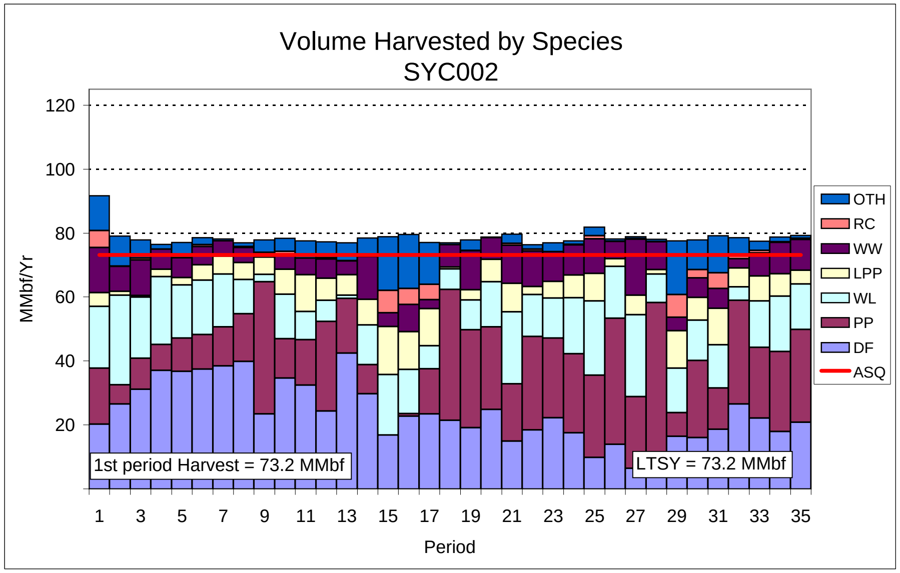
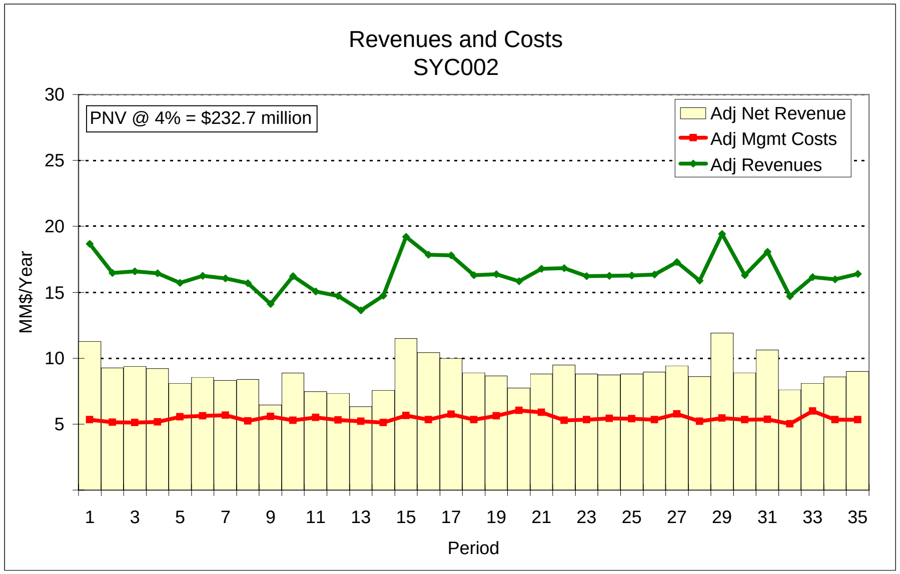
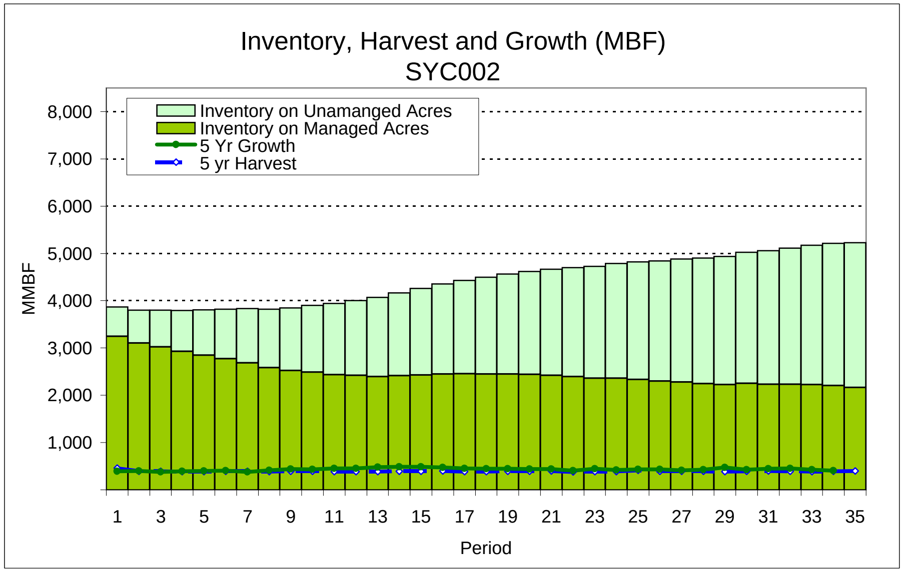
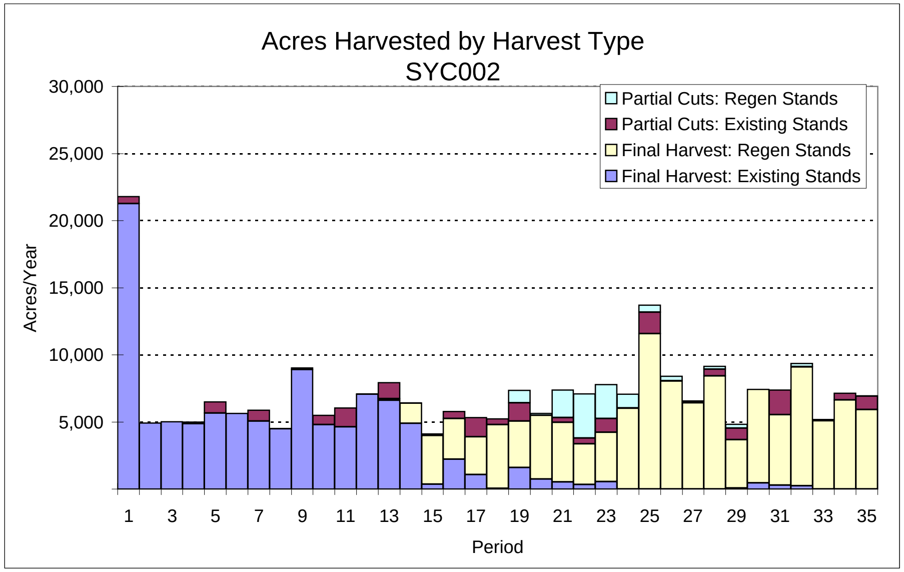
SYC002

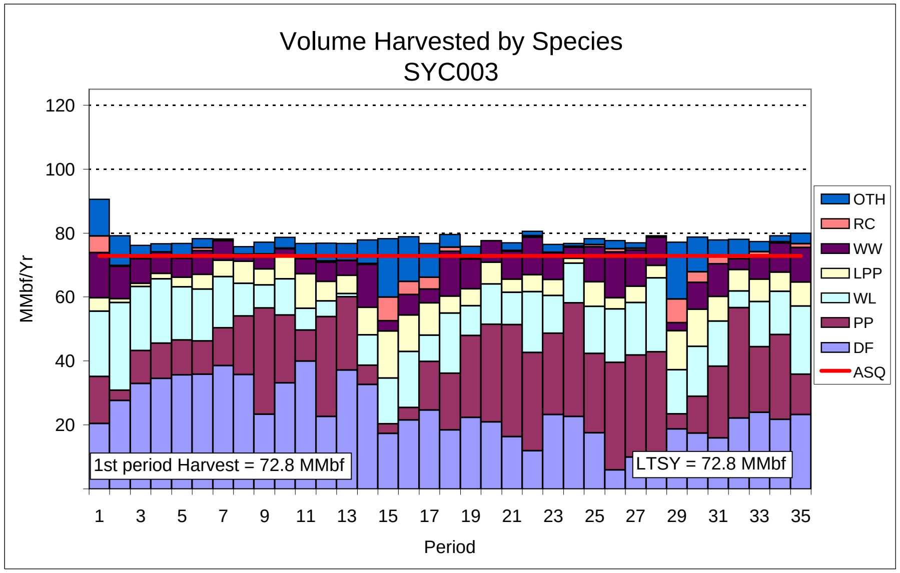


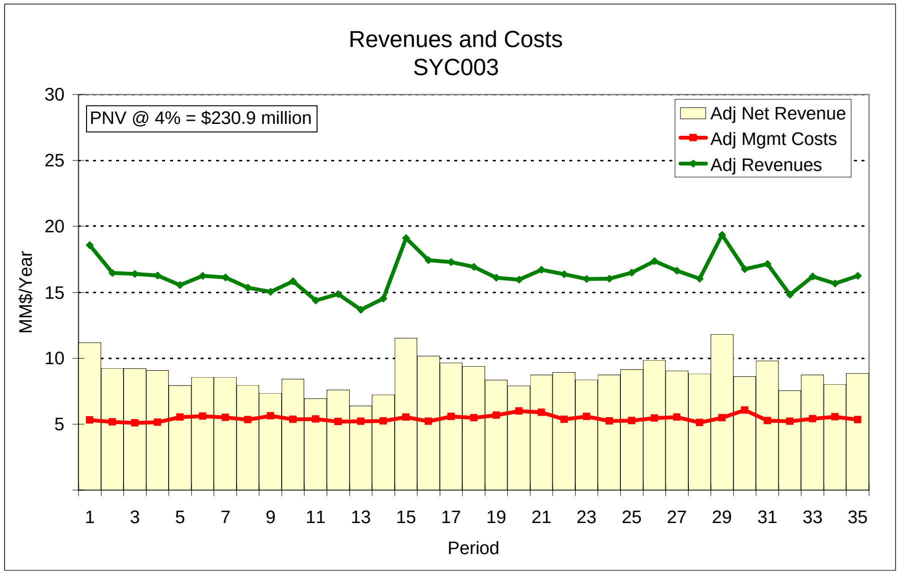


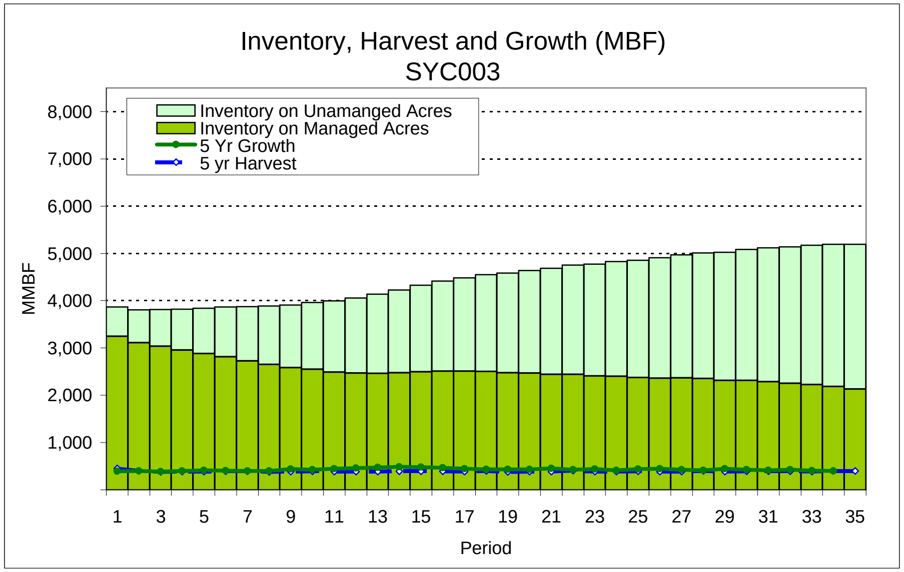


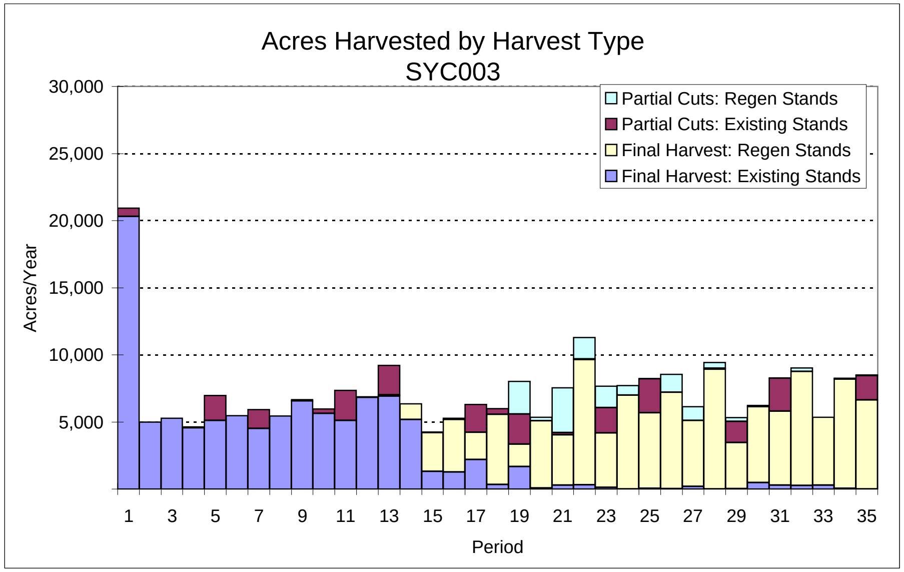


MT DNRC SYC Calculation
SYC003

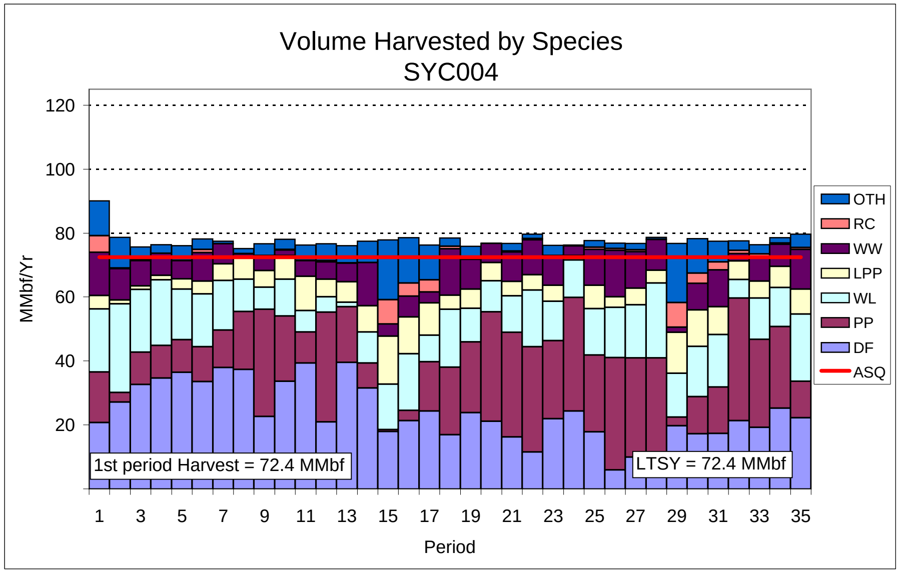


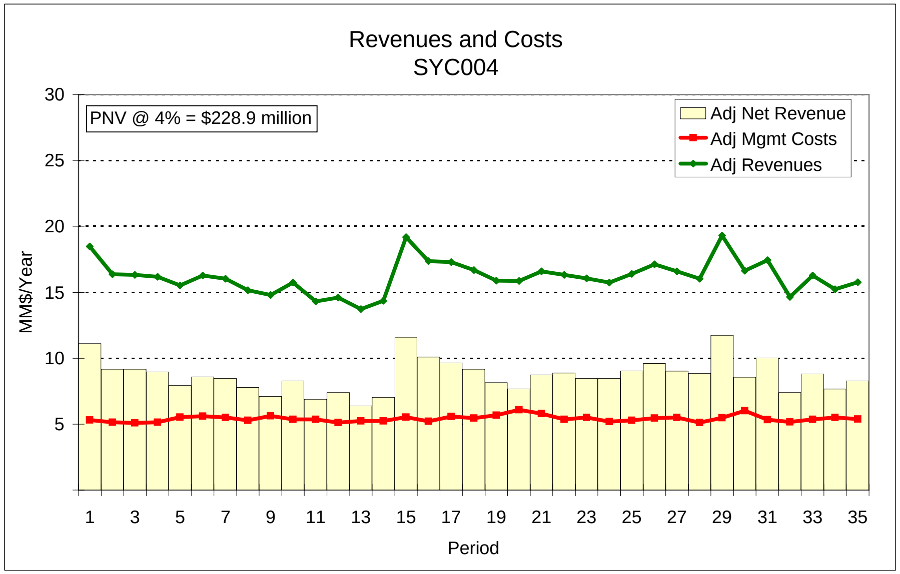


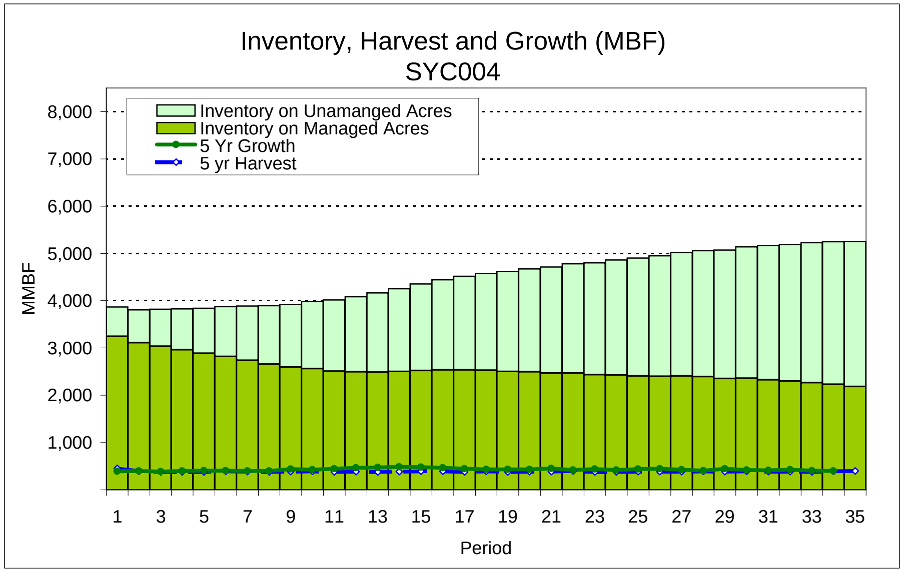


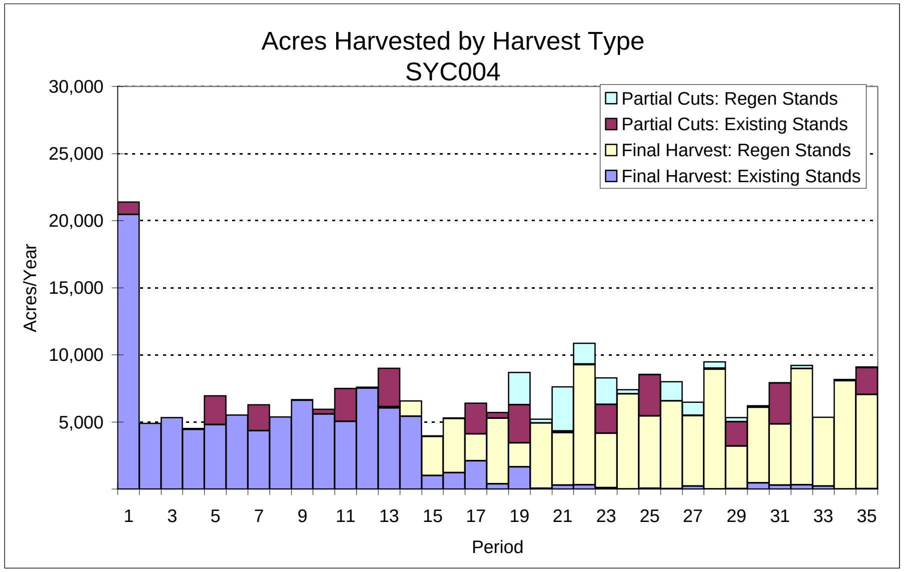


MT DNRC SYC Calculation
SYC004

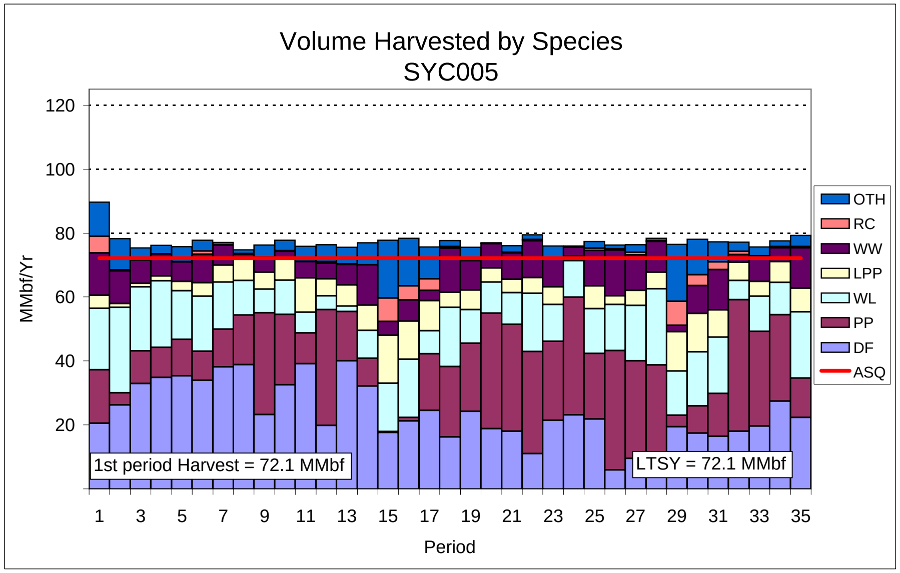


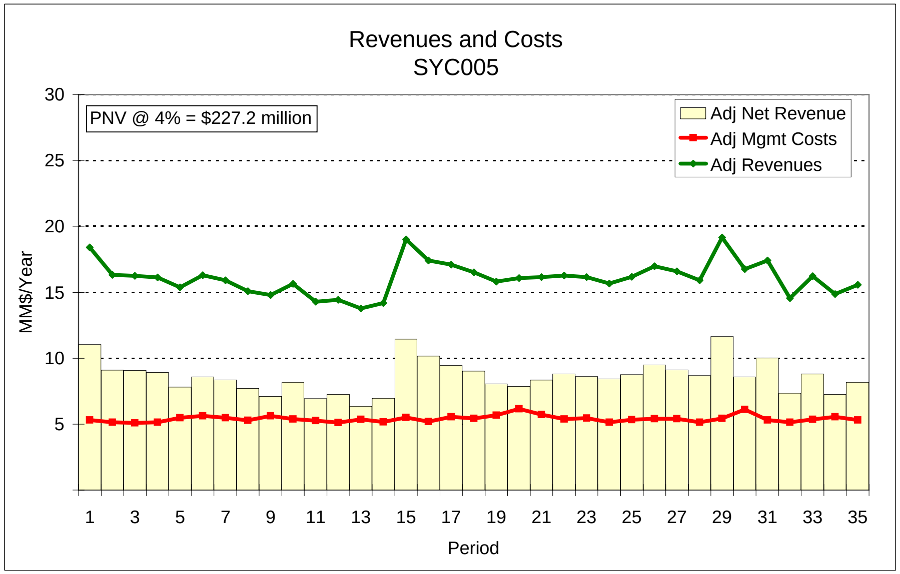


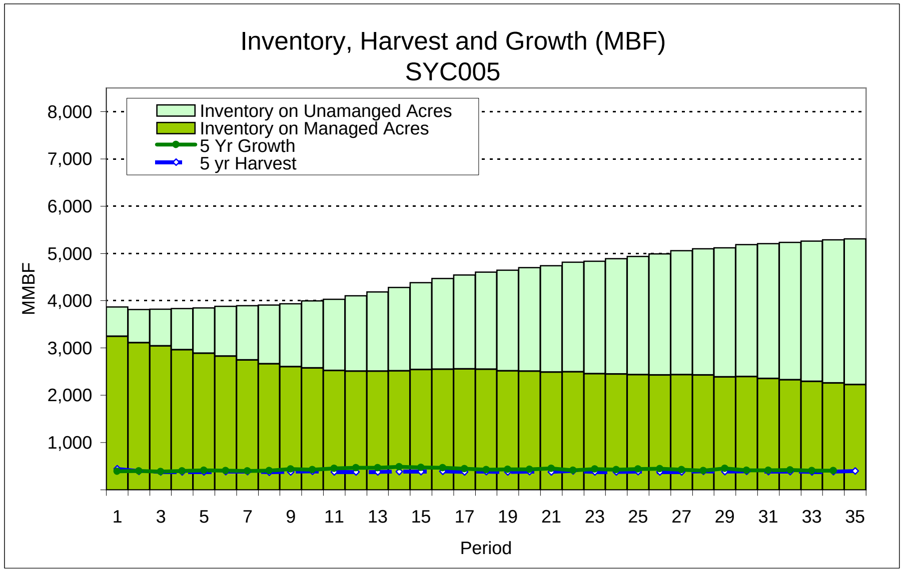


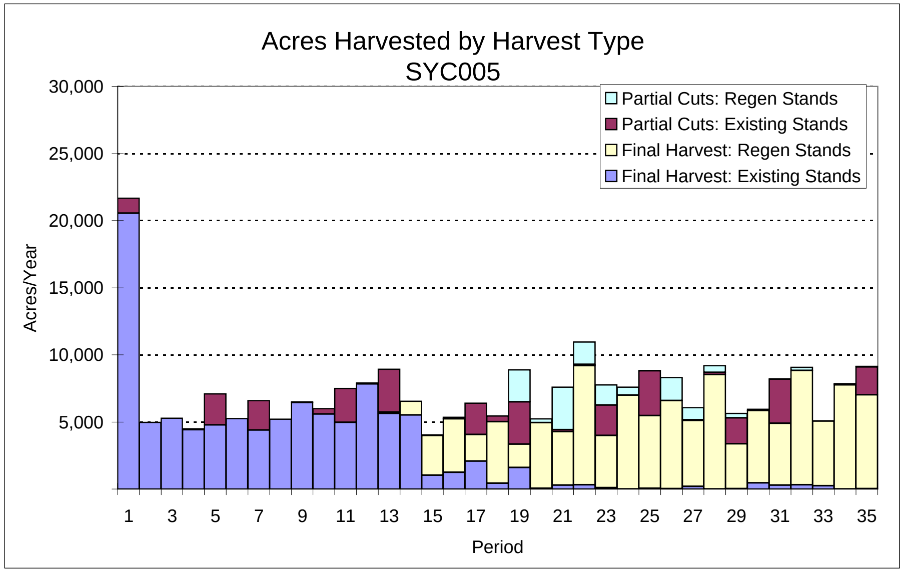


MT DNRC SYC Calculation
SYC005









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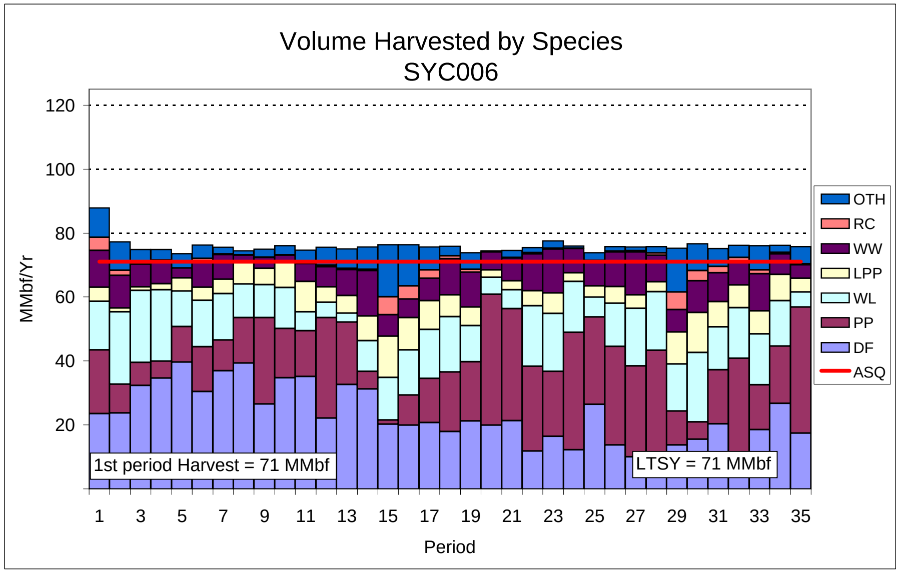
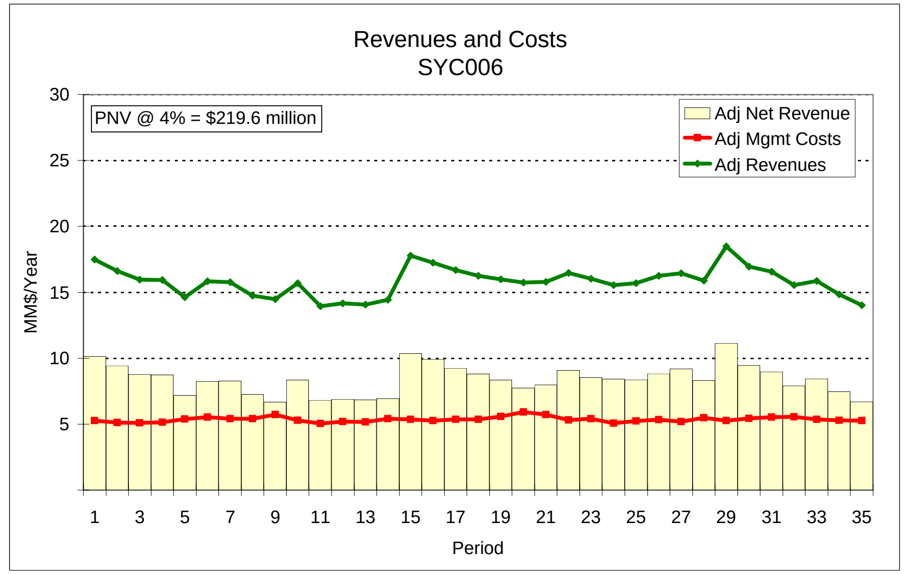
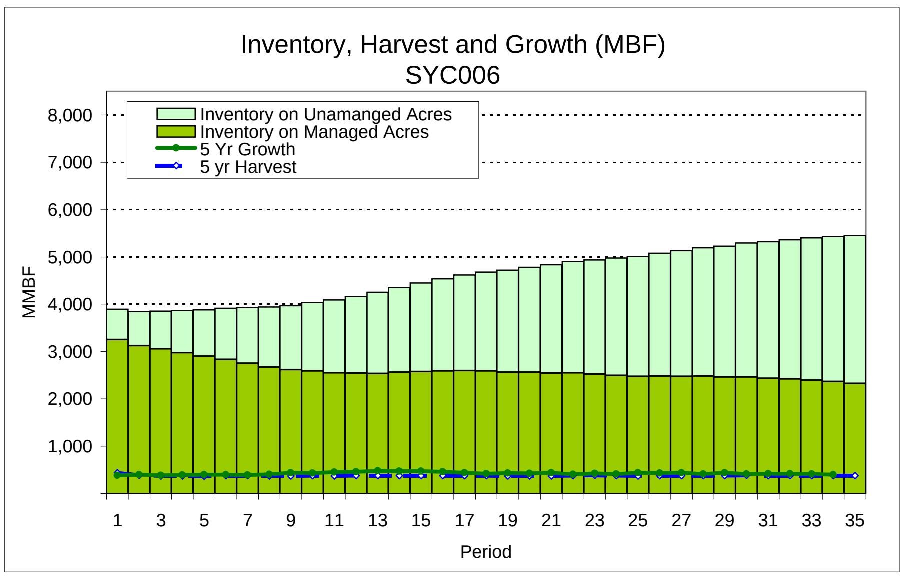
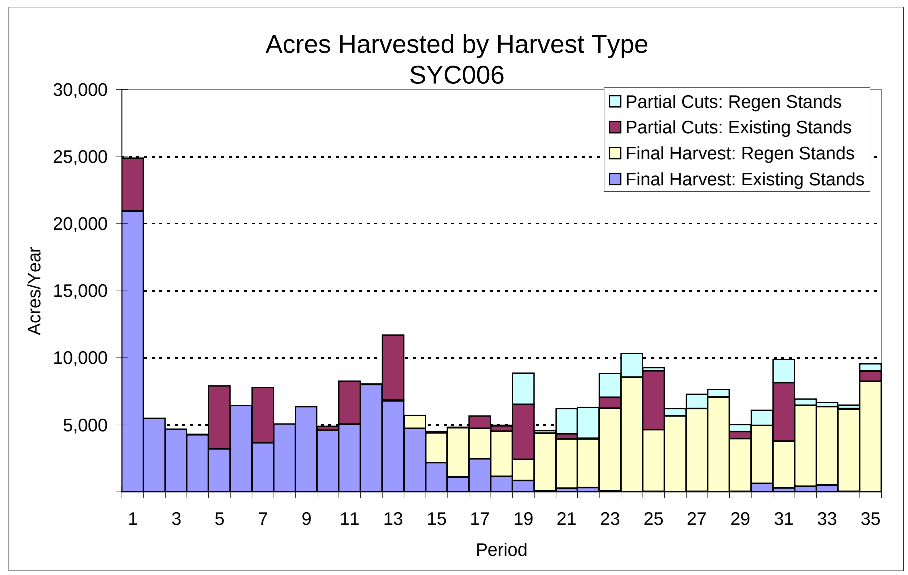
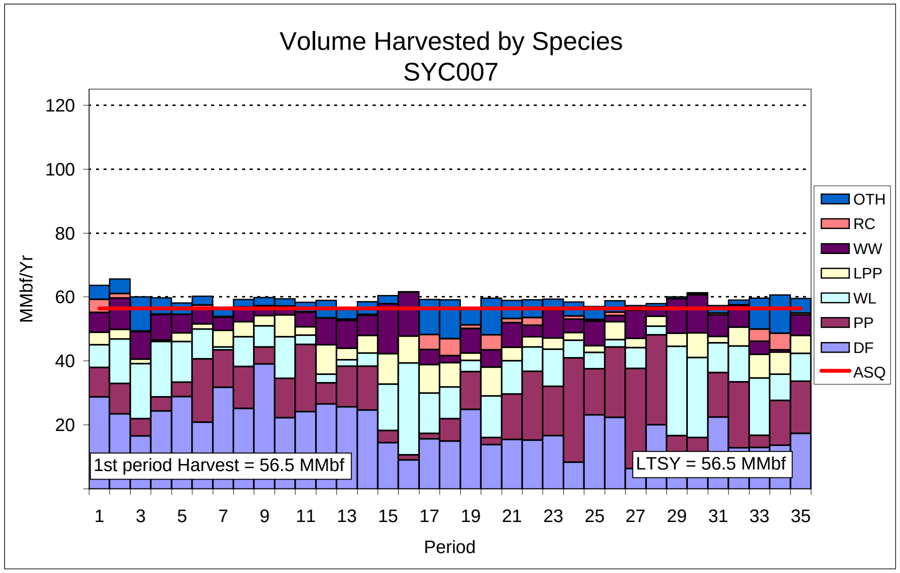


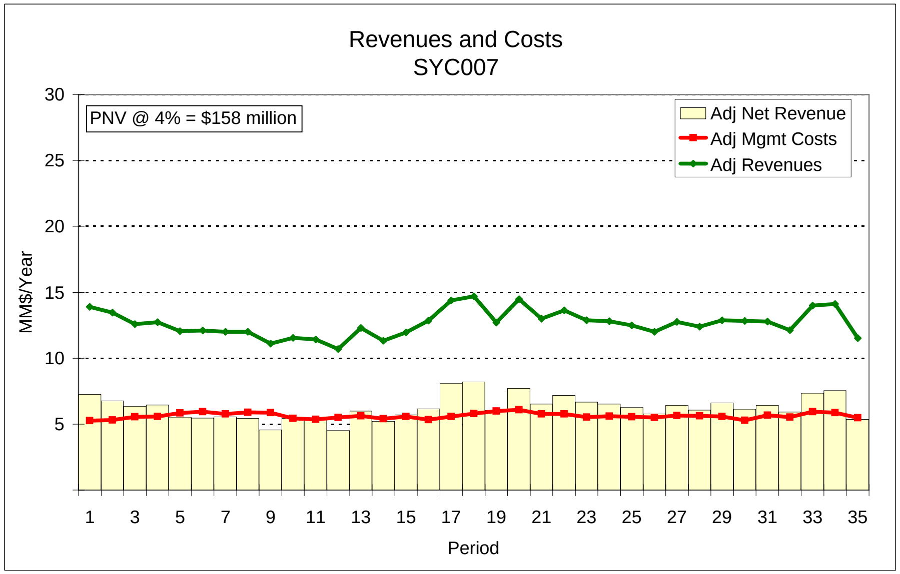


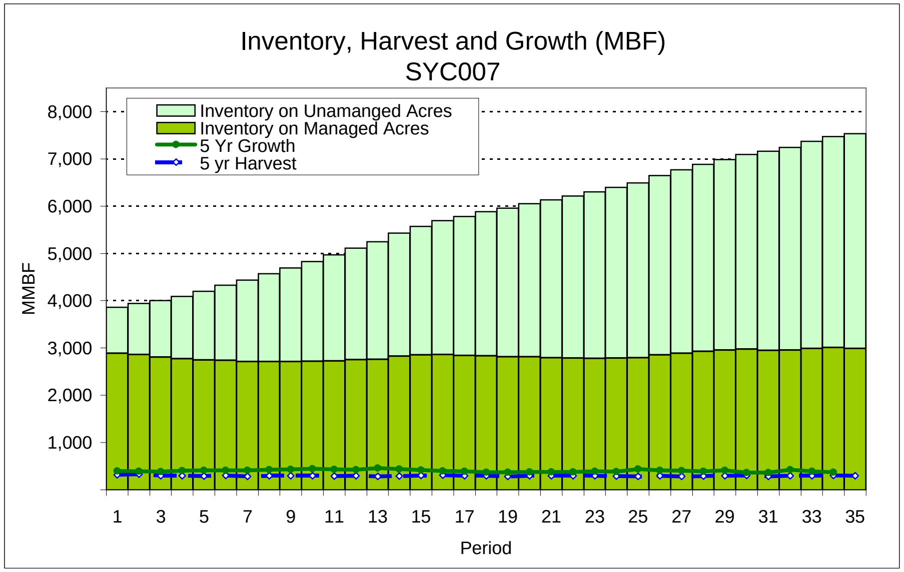


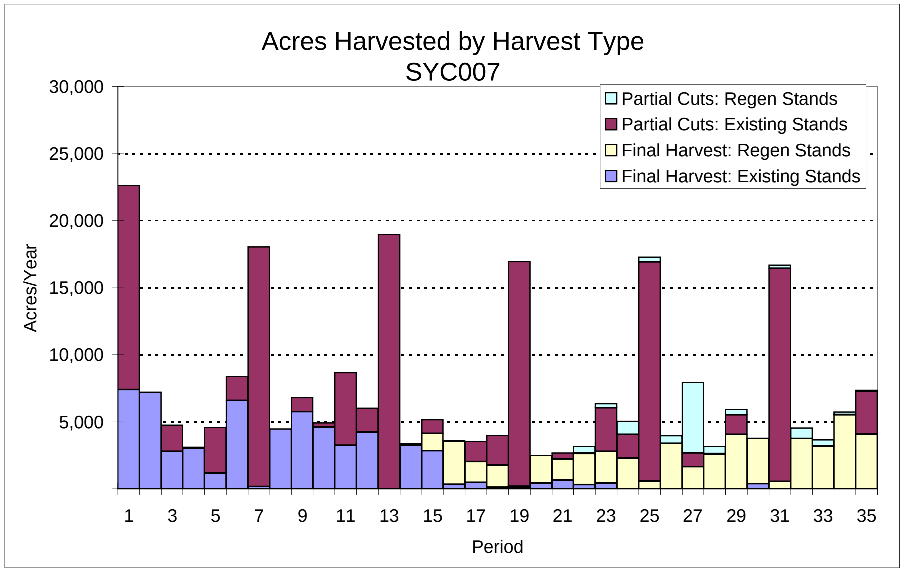


MT DNRC SYC Calculation
SYC007

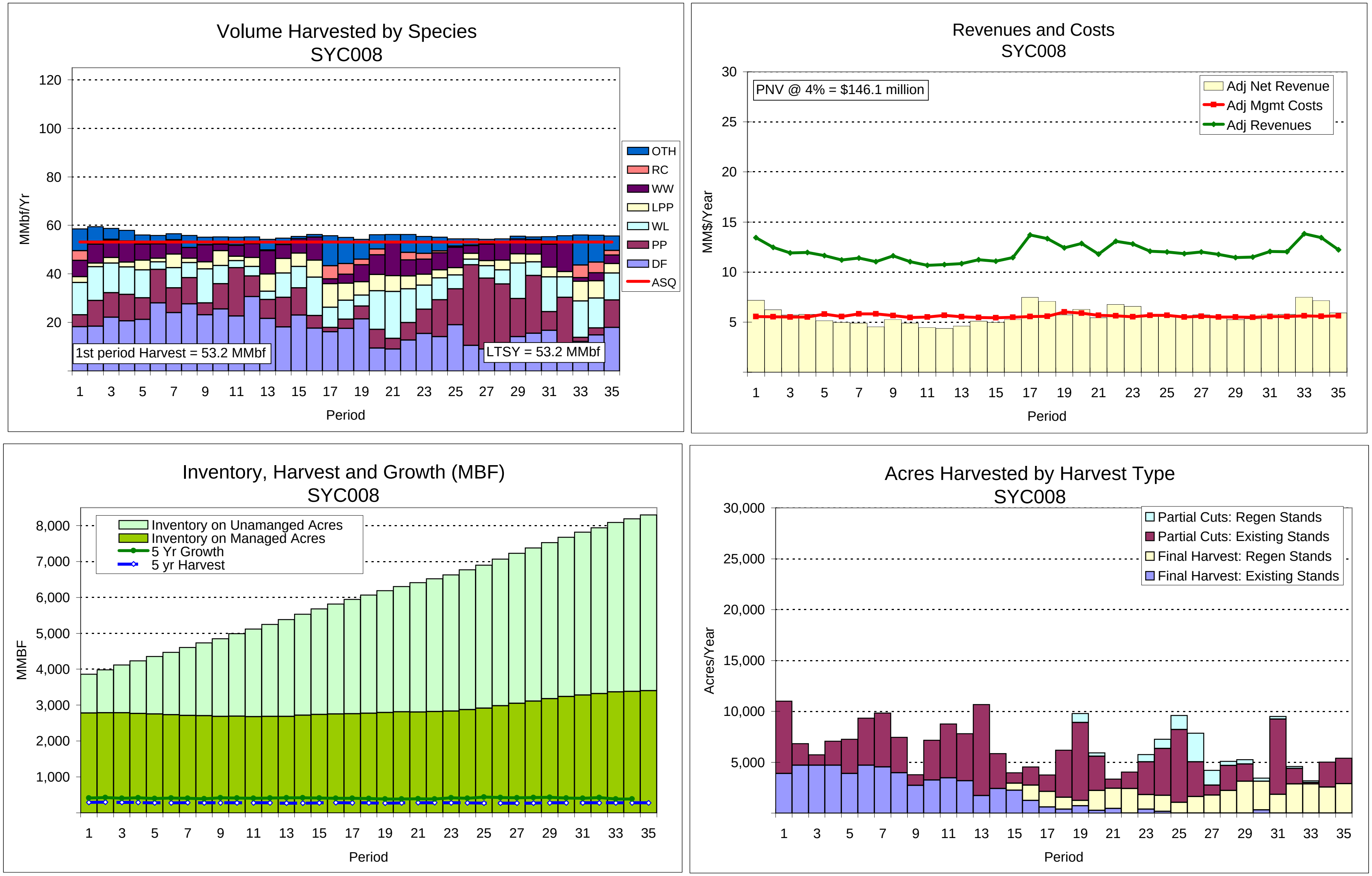






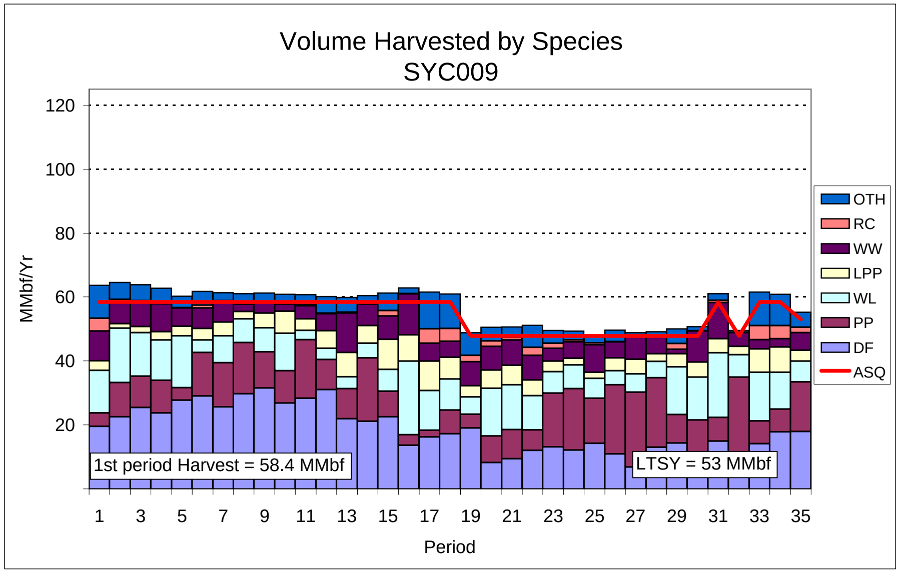


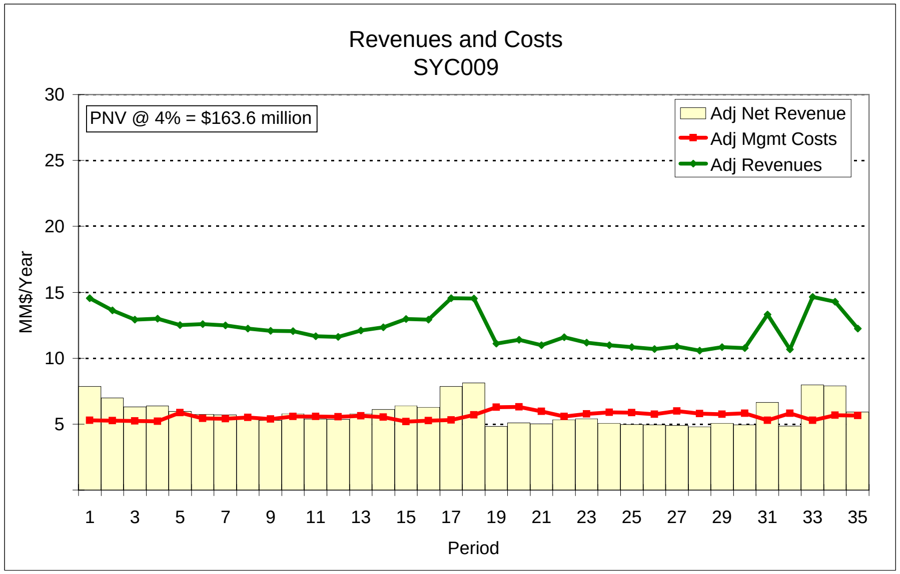
MT DNRC SYC Calculation
SYC008

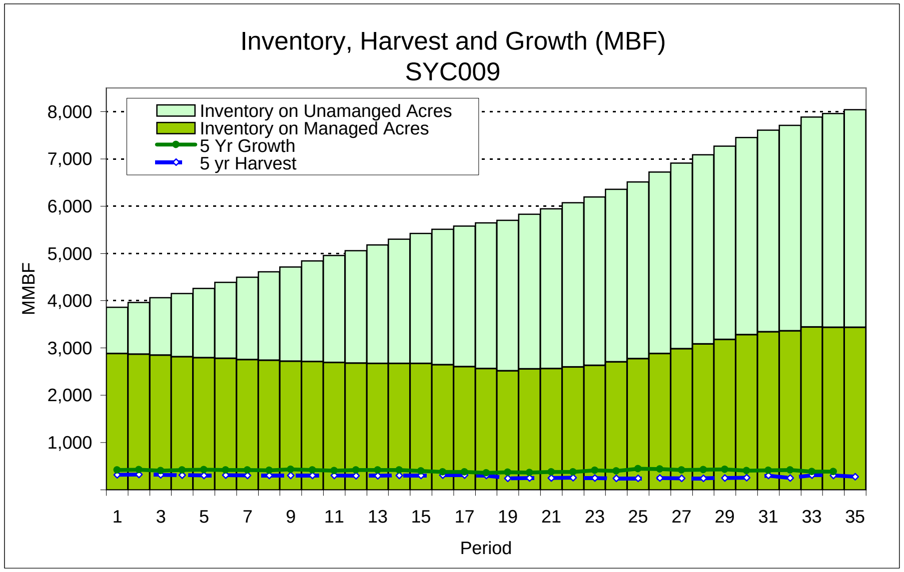


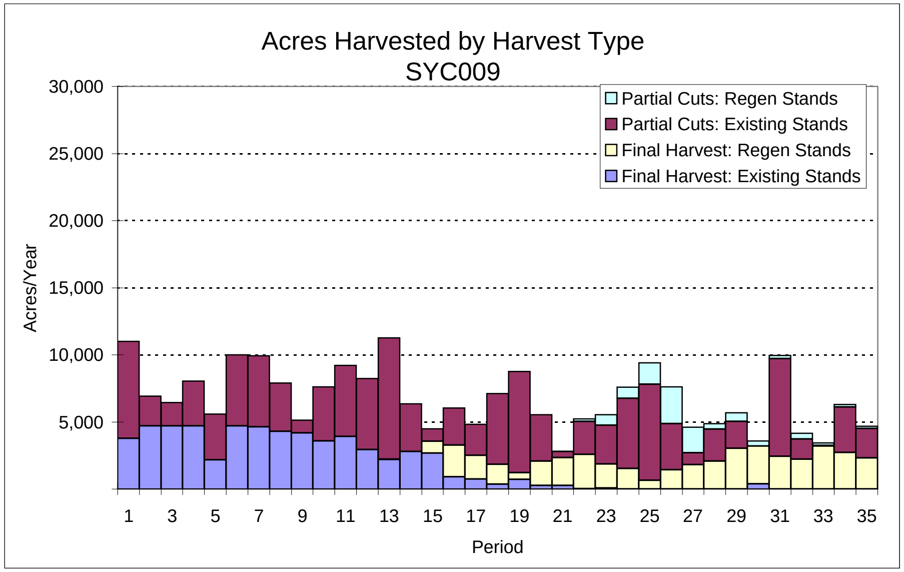
APPENDIX A

MT DNRC SYC Calculation
SYC009









MT DNRC SYC Calculation
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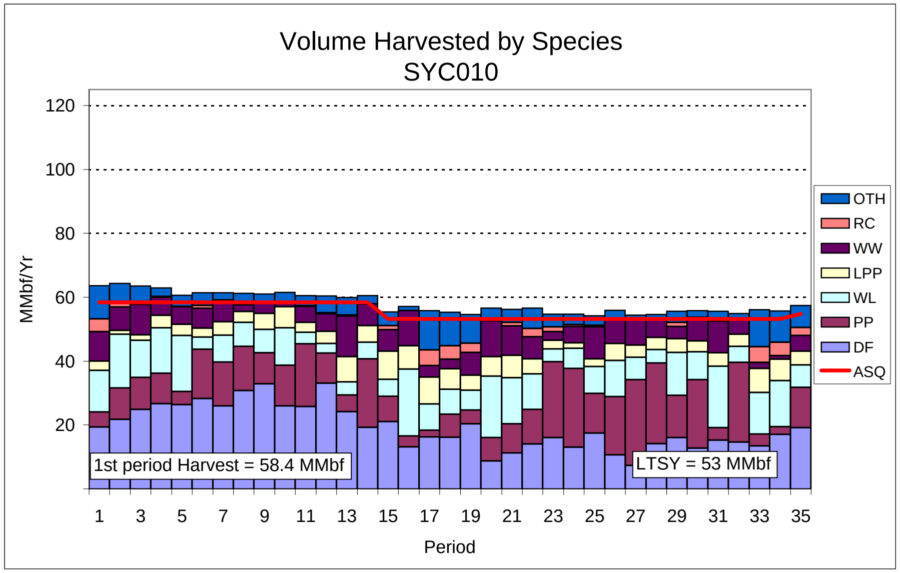

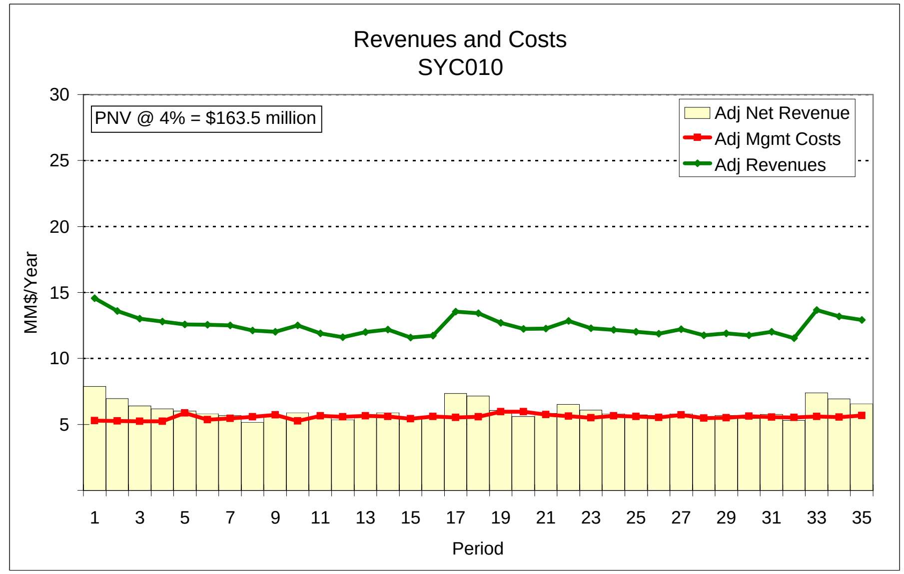

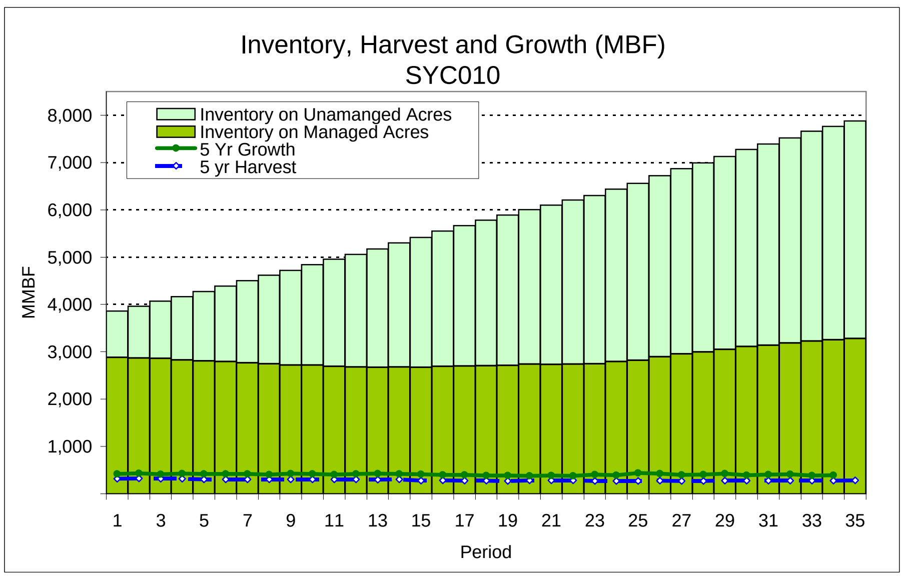

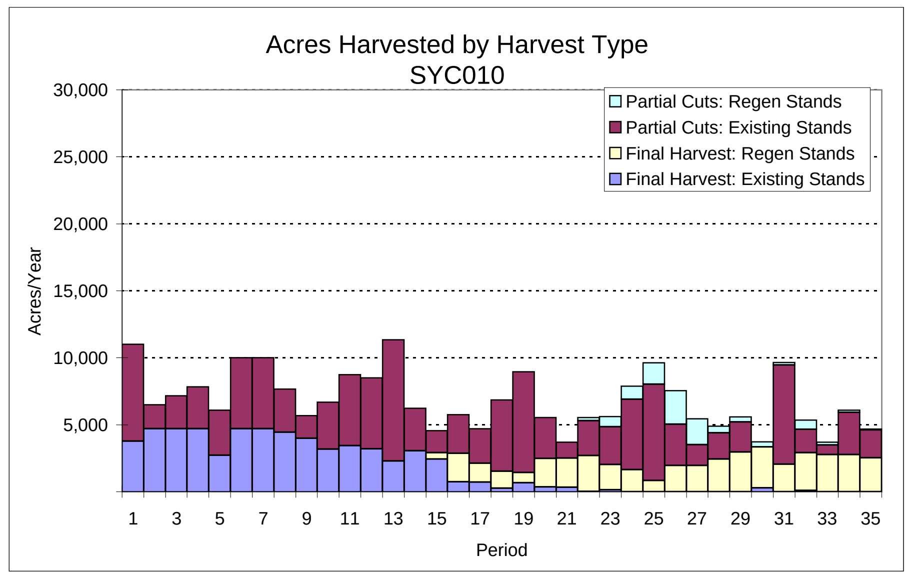

Appendix B

Compatibility Matrix

Compatibility Matrix
MT DNRC SYC Forest Management Model

Regime Name	Riparian		Grizzly Bear			Eagles		Old Growth			Deferred	Sensitive Watershed
	Fish Present	Fish Absent	Visual Buffer	Core & Buffer	Recov. Area	Nest Area	Primary Use Area	Moist	Dry	Cool		
Central and Eastern L0s												
No harvest	x	x	x	x	x	x	x	x	x	x	x	x
EAL076	x	x			x	x	x	x	x			x
Even-aged					x							x
ODF054					x		x	x	x			x
OPP044					x		x		x			x
PDF056					x		x	x	x			x
PPP046					x		x		x			x
REA062		x			x		x					x
REA082	x	x			x		x					x
UDF052					x		x					x
UPP042					x		x					x
Northwest LO												
No harvest	x	x	x	x	x	x	x	x	x	x	x	x
EAL076		x	x		x	x	x		x			x
Even-aged					x							x
OLF161	x	x	x		x	x	x	x	x			x
OPP058			x		x		x		x			x
PLF161	x	x	x		x	x	x	x	x			x
PPP051			x		x		x		x			x
RNW104		x	x		x	x	x					x
RNW164	x	x	x		x	x	x					x
ULF084			x		x		x					x
UMC124		x	x		x	x	x					x
UPP042			x		x		x					x
Southwest LO												
No harvest	x	x	x	x	x	x	x	x	x	x	x	x
EAL076		x			x	x	x					x
Even-aged					x							x
ODF058					x		x		x			x
OLF068					x		x	x	x			x
OMC128	x	x			x	x	x	x	x			x
OPP048					x		x		x			x
PDF051					x		x		x			x
PLF061					x		x	x	x			x
PMC121	x	x			x	x	x	x	x			x
PPP041					x		x		x			x
RSW084		x			x	x	x		x			x
RSW124	x	x			x	x	x					x
UDF052					x		x					x
UMC122		x			x	x	x					x
UPP042					x		x					x

SA=AF
LF=DL, western larch / Douglas-fir, etc

Appendix C

Acres in the Forest Management Model

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Total GIS Acres	1,219,745
Not DNRC	13,343
Roads	17,392
Water	2,290
Non Forest	460,058
Forested acres for the Model	726,662

In/Out

	InOut	Total	CE	EA	NE	NW	SO	SW
In the model	IN	726,662	116,838	50,587	59,066	288,101	57,546	154,524

Layer 1 -- Unit Grouping

	L1	Total	CE	EA	NE	NW	SO	SW
CLO	CE	116,838	116,838					
Eastern Los	East	167,199		50,587	59,066		57,546	
Northwest-remainder	NWW	133,695				133,695		
Stillwater	STW	116,125				116,125		
Soutwest	SW	154,524						154,524
Swan	SWN	38,281				38,281		
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Elevation

	LvElev	Total	CE	EA	NE	NW	SO	SW
High	H	64,247	29,126			21,777		13,344
Low	L	167,902				145,000		22,902
Medium	M	494,513	87,713	50,587	59,066	121,324	57,546	118,278
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Grizzly Bear

	LvGriz	Total	CE	EA	NE	NW	SO	SW
Not GZB	+	569,937	106,285	50,587	59,066	148,917	57,546	147,537
Core&Buffer	C	48,904				48,904		
Recovery	R	104,009	10,553			86,468		6,987
Visual Buffer	V	3,812				3,812		
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Eagle

	LvEagle	Total	CE	EA	NE	NW	SO	SW
Not Eagle	+	716,897	116,104	50,378	59,066	282,285	56,915	152,149
Eagle Nest	E	1,112	28	168		699	68	148
Primary Use	P	8,653	706	41		5,117	562	2,227
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Watershed Risk

	LvWater	Total	CE	EA	NE	NW	SO	SW
Not Sensitive	+	615,697	116,838	50,587	59,066	213,885	57,546	117,775
Sensitive	W	110,964				74,216		36,749
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Old Growth

	LvOg	Total	CE	EA	NE	NW	SO	SW
Not Old Growth	+	673,439	116,322	50,587	58,999	248,929	57,546	141,057
Old Growth	O	53,223	516		68	39,173		13,467
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Deferred Class

	LvLand	Total	CE	EA	NE	NW	SO	SW
Available	A	610,200	92,204	32,958	38,419	263,846	42,959	139,815
Deferred	D	116,462	24,634	17,630	20,647	24,256	14,587	14,709
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Layer 2 - Elevation, Grizzly Bear, Eagle, Watershed Risk, and Defered Class, Old Growth

	L2	Total	CE	EA	NE	NW	SO	SW
NCF	+	51,521	9,282	14,715	14,151	2,922	9,536	916
	H+++A+	32,421	23,721			1,022		7,678
	H+++AO	1,341	123					1,218
	H+++D+	3,542	2,268					1,274
	H+++DO	296	192					104
	H++WA+	1,771						1,771
	H++WAO	286						286
	H+P+A+	130	130					
	H+P+D+	22	22					
	HC++A+	3,099				3,099		
	HC++AO	1,264				1,264		
	HC++D+	1,313				1,313		

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Layer 2 - Elevation, Grizzly Bear, Eagle, Watershed Risk, and Defered Class, Old Growth (Continued)

L2	Total	CE	EA	NE	NW	SO	SW
HC++DO	281				281		
HC+WA+	3,522				3,522		
HC+WAO	3,085				3,085		
HC+WD+	325				325		
HC+WDO	1,253				1,253		
HR++A+	1,450				1,323		128
HR++AO	661				661		
HR++D+	1,109				337		772
HR++DO	365				316		50
HR+WA+	742				742		
HR+WAO	1,105				1,105		
HR+WD+	162				162		
HR+WDO	95				95		
HV+WA+	9				9		
HV+WAO	0				0		
L+++A+	91,984				74,888		17,096
L+++AO	5,206				4,928		278
L+++D+	7,394				4,674		2,720
L+++DO	242				136		106
L++WA+	7,511				6,451		1,059
L++WAO	1,104				832		273
L++WD+	570				528		42
L+E+A+	329				289		41
L+E+AO	0				0		
L+E+D+	127				83		44
L+EWA+	73				73		
L+EWAO	26				26		
L+EWD+	6				6		
L+P+A+	2,511				1,807		705
L+P+AO	42				12		30
L+P+D+	663				458		205
L+P+DO	9						9
L+PWA+	490				485		5
L+PWAO	468				445		23
L+PWD+	47				47		
LC++A+	1,235				1,235		
LC++AO	44				44		
LC++D+	228				228		
LC+WA+	1,279				1,279		
LC+WAO	151				151		

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Layer 2 - Elevation, Grizzly Bear, Eagle, Watershed Risk, and Defered Class, Old Growth (Continued)

L2	Total	CE	EA	NE	NW	SO	SW
LR++A+	24,232				24,232		
LR++AO	4,925				4,925		
LR++D+	2,799				2,799		
LR++DO	239				239		
LR+WA+	7,821				7,821		
LR+WAO	2,267				2,267		
LR+WD+	730				730		
LR+WDO	89				89		
LV++A+	1,408				1,408		
LV++AO	264				264		
LV++D+	58				58		
LV++DO	33				33		
LV+WA+	388				388		
LV+WAO	98				98		
LV+WD+	17				17		
LV+WDO	4				4		
M+++A+	257,080	54,316	25,736	32,875	42,498	37,025	64,631
M+++AO	10,566	200		68	3,068		7,230
M+++D+	58,550	18,018	9,977	11,973	2,603	10,441	5,538
M+++DO	967				202		765
M++WA+	31,461				2,403		29,058
M++WAO	2,515				174		2,341
M++WD+	821				29		792
M++WDO	31						31
M+E+A+	113	6				43	64
M+E+D+	166	18	123			25	
M+P+A+	1,147	278			14	170	685
M+P+AO	133						133
M+P+D+	590	246	36			307	
M+PWA+	372						372
M+PWD+	22						22
MC++A+	8,265				8,265		
MC++AO	605				605		
MC++D+	2,126				2,126		
MC++DO	84				84		
MC+WA+	14,385				14,385		
MC+WAO	3,059				3,059		
MC+WD+	473				473		
MC+WDO	121				121		
MCEWA+	17				17		

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Layer 2 - Elevation, Grizzly Bear, Eagle, Watershed Risk, and Defered Class, Old Growth (Continued)

L2	Total	CE	EA	NE	NW	SO	SW
MCEWAO	6				6		
MCPWA+	611				611		
MCPWAO	140				140		
MCPWDO	15				15		
MR++A+	23,494	7,166			12,577		3,751
MR++AO	5,384				4,867		517
MR++D+	3,660	849			1,577		1,234
MR++DO	555				481		74
MR+WA+	13,647				13,647		
MR+WAO	2,945				2,945		
MR+WD+	1,182				728		454
MR+WDO	352				352		
MREWA+	102				102		
MREWAO	98				98		
MRPWA+	827				827		
MRPWAO	157				157		
MV++A+	558				558		
MV++AO	43				43		
MV+WA+	741				741		
MV+WAO	87				87		
MV+WD+	20				20		
MVPWA+	79				79		
MVPWAO	4				4		
	726,662	116,838	50,587	59,066	288,101	57,546	154,524

Layer 3 -- Riparian Class

	L3	Total	CE	EA	NE	NW	SO	SW
NCF	+	51,521	9,282	14,715	14,151	2,922	9,536	916
Fish Absent	A	15,172	2,559	608	741	5,985	987	4,291
Fish Present	P	11,921	209		7	8,814	35	2,856
Upland	U	648,047	104,787	35,264	44,168	270,380	46,988	146,460
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Layer 4 -- Appropriate/Potential Vegetation

	L4	Total	CE	EA	NE	NW	SO	SW
NCF	+	51,521	9,282	14,715	14,151	2,922	9,536	916
Cool	AF	33,445	5,879		36	25,508		2,021
Dry	DF	120,179	73,362		3,960	6,431	2,715	33,711
	HW	6,444	1,763	1,018	848	611	1,126	1,079
Cool	LP	43,198	10,760		1,345	18,141	896	12,055
Moist	MC	21,015	747		299	18,757	124	1,089
Dry	PP	258,194	15,045	34,855	38,427	57,613	43,150	69,105
Moist	WL	159,908				125,743		34,165
Moist	WP	32,758				32,375		383
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Layer 5 -- Site Class

	L5	Total	CE	EA	NE	NW	SO	SW
NCF	+	51,521	9,282	14,715	14,151	2,922	9,536	916
High Site Class	H	198,761	54,914	1,742	5,237	97,788	9,535	29,544
Low Site Class	L	203,079	23,674	14,921	29,571	77,395	11,032	46,486
Medium Site Class	M	273,300	28,968	19,209	10,107	109,996	27,443	77,578
		726,662	116,838	50,587	59,066	288,101	57,546	154,524

Layer 6 -- Timber Class (Species Class, Size Class, Stocking Class)

Species Groups:

AF - Alpine Fir
CO - Cottonwood
DF - Doug Fir
DL - Doug Fir/Larch
GF - Grand Fir
GM - Grand Fir & Mixxed Conifer
HW - Hardwood
LP - Lodgepole
MC - Mixed Conifer
NC - Noncommerical
PL - Doug Fir, Larch, Pine
PP - Ponderosa Pine
QA - Quaking Aspen
RC - Red Cedar
SS - Subalpine Fir, Spruce

L6	Total	CE	EA	NE	NW	SO	SW
AF66MM	552	179			373		
AF77MM	2,100				2,100		
AF77WW	3,565	12			3,552		
AF88MM	1,992				1,992		
AF88PW	886	886					
AF99MM	22,192				22,192		
AF99MW	3,431	2,665					766
AF99PP	15,655	2,597			11,979		1,079
AF99WW	1,173				1,173		
CO79LW	775						775
CO79PW	278	278					
CO99PW	1,468		1,018	39		411	
DF66MM	9,647	5,744		46	227		3,630
DF77MM	5,276	420			2,796		2,060
DF77PP	665	627		16		22	
DF77WW	1,719	202		5	448		1,063
DF88MW	21,132	8,411					12,721
DF88PP	10,968	10,968					
DF88PW	704			259		446	
DF99MM	26,366						26,366
DF99MW	26,378	22,645		2,399		1,334	

Montana DNR Planning (2004)

Acres By LO Based on Montana SLI Database and Classifications

Size Class Codes:

66 - Non-stocked
77 - Seeds & Saps
88 - Poles
99 - Sawtimber

89 - Poles & Sawt
79- S&S, Poles, Sawt

Stocking Class Codes:

PP - Poor
MM - Medium
WW - Well

MW - Med & Well
PM - Poor & Med
PW - Poor, Med, Well

Layer 6 -- Timber Class (Species Class, Size Class, Stocking Class) (Continued)

L6	Total	CE	EA	NE	NW	SO	SW
DF99PP	43,200	24,822		1,551		1,045	15,782
DF99WW	5,924						5,924
DL66MM	1,920				1,920		
DL77MM	3,215				3,215		
DL77WW	6,953				6,953		
DL88MW	837						837
DL88PP	605						605
DL99MW	15,722						15,722
DL99PP	8,414						8,414
GF77WW	377				377		
GM99MM	8,684				8,684		
GM99PP	3,323				3,323		
GM99WW	8,327				8,327		
HW88PW	520				520		
HW99PW	634				634		
LP66MM	1,880	236			1,644		
LP66WW	291						291
LP77WW	13,275	602		16	9,383	36	3,238
LP88PM	874						874
LP88PW	10,101	2,248			7,854		
LP88WW	3,082						3,082
LP89PW	1,411			1,411			
LP99MW	9,389	4,651					4,738
LP99PP	6,752	3,024					3,728
LP99PW	8,013				8,013		
MC66MM	1,851				1,851		
MC77MM	953				953		
MC77WW	955				955		
MC88PW	732				732		
MC99PW	740						740
NC	51,521	9,282	14,715	14,151	2,922	9,536	916
PL88PM	2,587				2,587		
PL88WW	4,684				4,684		
PL99MM	71,314				71,314		
PL99PP	56,525				56,525		
PL99WW	34,308				34,308		
PP66MM	1,841	352	249	200		1,040	
PP66WW	6,184						6,184
PP77MM	217	25		177		15	
PP77PP	412	15	11	23		363	
PP77WW	1,122			11			1,112
PP88MW	4,225	1,579	886	1,172		587	

Montana DNR Planning (2004)
Acres By LO Based on Montana SLI Database and Classifications

Layer 6 -- Timber Class (Species Class, Size Class, Stocking Class) (Continued)

L6	Total	CE	EA	NE	NW	SO	SW
PP88PM	883						883
PP88PP	21,001	2,833	5,369	6,878		5,923	
PP99MW	46,851	2,298	9,016	9,722		13,843	11,972
PP99PP	90,051	7,672	19,324	20,157		22,231	20,667
QA79PW	1,594	47		833		715	
QA88PW	1,458	1,458					
QA89LW	354						354
RC99WW	2,656				2,656		
SS77PP	61	61					
SS88MW	934				934		
	726,662	116,838	50,587	59,066	288,101	57,546	154,524

Stocking (TOTSTK and SAWSTK)

STK	Total	CE	EA	NE	NW	SO	SW
L	27,856				3,145		24,711
M	249,825	40,509	12,029	14,413	115,224	15,532	52,118
P	312,241	60,099	38,243	42,295	83,661	37,810	50,133
W	110,611	9,554	43	2,113	79,983	1,477	17,441
X	26,129	6,676	272	246	6,088	2,727	10,121
	726,662	116,838	50,587	59,066	288,101	57,546	154,524

SSC

SSC	Total	CE	EA	NE	NW	SO	SW
6	26,129	6,676	272	246	6,088	2,727	10,121
7	43,546	2,164	74	434	32,382	569	7,923
8	95,250	33,784	11,445	13,867	18,659	10,373	7,123
9	561,737	74,215	38,796	44,519	230,973	43,877	129,357
	726,662	116,838	50,587	59,066	288,101	57,546	154,524

SSC vs. STK

		STK				
SSC	Total	L	M	P	W	X
6	26,129					26,129
7	43,546	171	14,385	9,223	19,768	
8	95,250	261	20,416	51,806	22,767	
9	561,737	27,424	215,024	251,213	68,076	
	726,662	27,856	249,825	312,241	110,611	26,129

Appendix D

Summary of Uneven-Aged Management Regimes

Appendix D

Summary of Management Regimes

MT SYC Forest Management Model   MT DNRC Forest Management Model

Management Emphasis	Land Office	Potveg, or geographic applicability	Residual BA	Number of retained large trees	Minimum size of retained large trees	Re-entry Period (years)	Regime Name	COMMENTS
Eagle	ALL	ALL	100	10	21	30	EAL076	
Old growth	NW	LF, MC, WP	160	10	21	30	OLF161	
Old growth	NW	AF	120	10	17	30	OAF121	
Old growth	SW	MC	120	8	21	30	OMC128	
Old growth	SW	LF, WP, AF	65	8	21	30	OLF068	
Old growth	NW	PP, DF	55	8	21	30	OPP058	
Old growth	SW	DF	55	8	21	30	ODF058	
Old growth	EA	DF, ALL OTHERS	55	4	17	30	ODF054	
Old growth	SW	PP	45	8	21	30	OPP048	
Old growth	EA	PP	45	4	17	30	OPP044	
Old growth plus	NW	LF, MC, WP	160	12	21	50	PLF161	
Old growth plus	NW	AF	120	12	17	50	PAF121	
Old growth plus	SW	MC	120	10	21	50	AMC121	
Old growth plus	SW	LF, WP, AF	65	10	21	50	ALF061	
Old growth plus	NW	PP, DF	55	10	21	50	APP051	
Old growth plus	SW	DF	55	10	21	50	ADF051	
Old growth plus	EA	DF, ALL OTHERS	55	6	17	50	ADF056	
Old growth plus	SW	PP	45	10	21	50	APP041	
Old growth plus	EA	PP	45	6	17	50	APP046	
Riparian	NW	STW, SWAN, Libby	160	NA	NA	30	RNW164	FISH
Riparian	SW	Kalispell, Plains, SWLO except Anaconda	120	NA	NA	30	RSW124	FISH
Riparian	NW	STW, SWAN, Libby	100	NA	NA	30	RNW104	NO FISH
Riparian	EA	Anaconda and all LO's to east	80	NA	NA	30	REA082	FISH
Riparian	SW	Kalispell, Plains, SWLO except Anaconda	80	NA	NA	30	RSW084	NO FISH
Riparian	EA	Anaconda and all LO's to east	60	NA	NA	30	REA062	NO FISH
Uneven aged	NW	MC	120	4	21	30	UMC124	
Uneven aged	SW	MC	120	2	21	30	UMC122	
Uneven aged	NW	LF, WP, AF	80	4	21	30	ULF084	
Uneven aged	SW	DF, WP, AF, LF	55	2	21	30	UDF052	
Uneven aged	EA	DF, ALL OTHERS	55	2	21	30	UDF052	
Uneven aged	NW	PP, DF	45	2	21	30	UPP042	
Uneven aged	SW	PP	45	2	21	30	UPP042	
Uneven aged	EA	PP	45	2	21	30	UPP042	

Appendix E

Interaction between the Forest Plan Constraints and the Non-Declining Yield Constraint

Appendix E

Interaction between the Forest Plan Constraints and the Non-Declining Yield Constraint

When the Forest Plan constraints are imposed on a model with a non-declining yield constraint, the model assigns a number of acres to the no-harvest regimes. The explanation behind this phenomenon is somewhat technical and can best be understood through a simple example.

Suppose there is a 100 acre forest of one type that has 100 units of timber per acre. We are interested in calculating a sustainable yield over two periods, P1 and P2.

We can allocate acres between two management regimes:

- Regime E is an even-aged regime. The future stand will be more productive than the existing stand, as it will have more desirable stocking, brush control, etc. Clearcutting the stand in P1 yields 100 units per acre. The stand can then be clearcut again in P2 yielding 110 units per acre.
- Regime U is an uneven-aged regime. The first entry in P1 reduces stocking to desired levels, yielding 50 units per acre. The second entry in P2 harvests the growth on the residual stand, and yields only 40 units per acre.

The variables in the problem are:

E = number of acres assigned to the even-aged regime
U = number of acres assigned to the uneven-aged regime

We can represent this problem with two equations:

1. All of acres must be allocated between these two regimes:

   $$U + E = 100$$

2. The harvest in Period 1 must be equal to the harvest in Period 2

   $$H1 = H2$$

   Where:

   $H1 = 100E + 50U$
   $H2 = 110E + 40U$

   Therefore:

   $$100E + 50U = 110E + 40U$$

The solution here is E=50 and U = 50. In short, the decline in harvest from the U regime is offset by the increase in harvest from the E regime on an acre by acre basis.

Now suppose that we have a new constraint limiting the number of acres that can be assigned to the E regime to 40. We have to add a new variable:

Z = acres assigned to the “no-harvest” regime.

Our problem then becomes:

$$E + U + Z = 100$$

$$E <= 40$$

$$100\,E + 50\,U + 0Z = 110\,E + 40\,U + 0Z$$

The solution is E = 40, U = 40 and Z = 20. In short, the new limit on the number of acres that can be assigned to E results in 20 acres going to the no-harvest prescription.

Under a non-declining yield constraint, each acre of the U regime requires one acre of E regime to offset the declining volume from the U regime. A limit on the acres that can be assigned to the E regimes translates into a limit on the acres that can be assigned to the U regimes as well. As a result, some acres must take the no-harvest Z regime.

This is a highly simplified version of what is happening in the Forest Management Model. In general, however, the even-aged regimes produce somewhat higher volumes in future rotations. The uneven-aged regimes produce somewhat lower volumes in future entries. As a result, limiting the number of acres that can be assigned to even-aged regimes, forces some acres to the no-harvest regime, given the non-declining yield constraint.

Appendix F

Wildlife And Hydrologic Constraints Incorporated into the Forest Management Model

Appendix F

Wildlife and Hydrologic Constraints Incorporated into The Forest Management Model

Wildlife

Bald Eagle.
Nests sites are defined and concentric circles of limited harvest are defined for nest site areas and primary use areas. Only uneven age regimes will be applied in these areas.

1. Maintain the distinction between nest site areas and primary use areas.
2. Apply to the nest site areas an uneven-aged regime that retains 100 sq.ft. of basal area and the ten largest trees.
3. Restrict the primary use areas to not allow stand-replacement harvesting. Any treatments applied would be uneven aged regimes. Retain the number of large live trees committed to in the snag and snag recruit rules.

This is how we modeled for eagles in the last sustained yield effort with the addition of not allowing stand replacement harvest in the primary use areas.

Gray Wolf
No specific requirements in rules that can be modeled. No expected yield consequences due to rules commitments.

Grizzly Bear.
Grizzly bear core area will be removed from harvest consideration. A ¼ mile buffer around core is off-limits to harvesting as well except as defined in the core map.

Hiding cover is required to be provided on a minimum of 40% of a bear management unit within the blocked portions of the Stillwater, Coal and Swan State Forests. Hiding cover is defined as 200 TPA > 1" DBH (or a relative density of approximately 5).

Visual screening is required on all open roads within the blocked portions of the Stillwater, Coal and Swan State Forests. This will be modeled as an uneven-age regime applied within a 200 ft. buffer along all open roads.

Canada Lynx
No specific requirements in rules that can be modeled. Pre-commercial thinning mitigations are not specifically modeled in sustained yield calculations because of the treatment of regenerated stands. The model requires all young stands to be of a sufficient size (height and dbh) for growth forecasting. Young stands provided to the model are already past the age of mitigation for lynx when they enter the model. The rules call for mitigations on dense young stands until the average size of crop trees exceeds 15 feet. The model mitigates for lynx by retaining these dense stands until they have fulfilled the desired mitigation.

Flammulated Owl
No specific mitigations required in rules. Silvicultural regimes on sites with potential flammulated owl habitat are designed to provide the conditions preferred by owls including favoring retention of large ponderosa pine, snag and snag recruit retention, multi-storied structure, and lowered stand density.

Pileated Woodpecker
Snag and snag recruit mitigations called for in rules are incorporated into all silvicultural regimes. CWD mitigations are not modeled. Silvicultural regimes are designed to favor retention of tree species preferred by pileated woodpeckers.

Fisher
The full range of mitigations for fisher called for in rules are incorporated into the riparian management regimes (see below) with one exception. The retention of at least one forested patch connecting third order watersheds is not modeled due to the lack of spatial specificity in the model. All silvicultural regimes retain snag and snag recruits in sufficient numbers to meet rules commitments.

Common Loon
No specific mitigations are being modeled. The expectation is that riparian harvest restrictions will provide for loon mitigations with no anticipated yield consequences.

Peregrine Falcon
No specific mitigations are being modeled.

Big Game
No specific mitigations are being modeled. Big game direction from the rules suggest coarse filter management will provide for adequate habitat. Coarse filter approach is the foundation for most silvicultural regimes.

Snag and Snag Recruits
Every harvested stand will remove from harvest a sufficient number of live trees to meet our commitment. We are assuming that one snag of sufficient size will be present for modeling purposes. Thus, for dry sites we will remove from harvest 1 large live tree, while the moist sites will remove from harvest 3 large live trees. The model kills trees throughout the growth projection, but it does not keep track of them after they die. Consequently, we cannot track snag numbers with the model.

Riparian Regimes and Constraints

REGIMES
Specific uneven-age regimes have been developed for two types of riparian management: fish bearing streams and non-fish bearing. Each class will be assigned one of three basal area retention levels based on geographic location.

Table 1. Residual basal areas in riparian and streamside management zones by fish presence or absence and geographic location (Unit office).

Unit Offices	Non-fish bearing	Fish bearing
Libby, Stillwater, Swan	100	160
Kalispell, Plains, MSO, CLW, Ham	80	120
Anaconda and eastside	60	80

RIPARIAN BUFFER WIDTHS

Riparian buffer widths are determined based on site potential tree height. For the modeling effort we used the following widths:

Table 2. Riparian and streamside management zone widths by fish presence or absence and geographic location (Unit office).

Unit Offices	Non-fish bearing	Fish bearing
Libby, Stillwater, Swan	50 ft.	120
Kalispell, Plains, MSO, CLW, Ham	50	100
Anaconda and eastside	50	80

The widths presented in Table 2, represent site potential tree height at age 100 for high site indexes within the respective geographic areas.

Constrained Watershed Procedures

Constraints were developed for sensitive watersheds to protect against the effects of increased streamflow.

The process first identifies the sensitive watersheds. They are grouped according to Unit office. Each Unit will have an associated level of non-hydrologically recovered acres that cannot be exceeded. We selected a stand age of 40 years since harvest to represent the threshold for hydrologic recovery based on published and unpublished research. We estimate that recovery will exceed 85% after 40 years based on the research. This level is anticipated to provide assurances against negative impacts of increased streamflow.

We then determined a percentage of the landscape that could exist in a non-recovered condition. We base the percentage on historical conditions in Montana forests (Losensky 1997). Each unit has a corresponding percentage linked to a total number of acres as shown in Table 3, below.

When a stand-replacement harvest is imposed, those acres go into the pool of non-recovered acres where they remain until a stand age of 40 is reached. The acres then go into the pool of recovered acres. Partial harvests do not affect the calculation as sufficient tree cover is expected to remain to prevent hydrologic impacts from increased flow. Stand replacement burns will count in the total of non-recovered acres.

Table 3, shows the total acres in sensitive watersheds and the maximum acres that can exist in a non-recovered condition by Unit office. The "maximum non-recovered acres" apply only within the "total acres in sensitive watersheds". Thus, any stand replacement harvest or burn that occurs within a sensitive watershed will add to the number of acres in a non-recovered condition. After 40 years those acres are moved out of the non-recovered state and into a recovered condition. While it is anticipated that most of the hydrologic impact from stand replacement harvest occurs from harvesting wetter sites, the maximum applies to the all the acres within each specific sensitive watershed.

Table 3. Maximum acres allowed in a non-recovered condition within sensitive watersheds by Unit office.

Unit Office	Total Acres in Sensitive Watersheds	Max Non-recovered acres	Max Percent in Non-recovered
ANA	2,550	740	29%
CLW	13,342	3,895	29
HAM	16,072	4,661	29
KAL	3,948	1,421	36
LIB	4,603	1,657	36
MSO	9,431	2,735	29
PLN	641	231	36
STW	58,050	20,898	36
SWN	9,148	3,293	36

Appendix G

Modeling Old Growth

Appendix G
Modeling Old Growth

Background

Although the rules do not require DNRC to set aside Old Growth (OG), the planning model must make provisions for tracking OG and for meeting the intention of the Forest Management Rules (FRM) and the State Forest Land Management Plan (SFLMP) regarding landscape-level biodiversity considerations.

The definition of OG is based on Green, et. al., (1992) and was adopted by the Land Board in 2001 after extensive public involvement. Some simplifications of the Green definitions were required for the modeling effort. The OG definition is based on meeting minimum criteria for numbers of large trees per acre, their diameter at breast height, and age. As shown in the table below, these minimums vary by geographic location and by the Potential Vegetation (PotVeg) class.

Table 1. Westside old growth definitions

POTVEG	Minimum Age	TPA	Minimum SIZE
WP	180	10	21"
PP	170	8	21"
DL	170	10	21"
DF	170	8	21"
LP	140	10	13"
MC	180	10	21"
AF	180	10	17"

Table 2. Eastside old growth definitions.

POTVEG	Minimum Age	TPA	Minimum SIZE
PP	180	4	17"
DF	200	5	17"
LP	150	12	10"
SF	160	7	17"

The SLI identifies stands meeting these conditions. In addition, the SLI identifies stands that are likely to meet these conditions, based on other stand characteristics.

Data Limitations

The plot data used to prepare the starting stand tables for each timber type (Land Office, species, size class, stocking class) did not separate plots potentially in OG stands from plots in the rest of the sawtimber size class. In other words, stand tables specific to old growth were not developed. As a result, the OG stands and the sawtimber stands have the same set of beginning stand tables.

The Green OG definition is based on both tree size and tree age. Tree ages were measured for a subset of the trees in the plots used to create the beginning stand tables. Tree ages for the rest of the trees were estimated using age/height equations derived from the measured trees – one equation for each species in each Land Office. The plot data, however, does not include tree ages greater than 200 years old – this field procedure was designed to save time counting tree rings during data collection. This caused the predicted age for the largest trees to be biased towards a younger age. Since the equations were not developed using trees across the entire age/height distribution, they will not typically yield estimated tree ages that meet or exceed the Green OG definition (>170 years old).

As a result of these data limitations, a calculation of when timber types in the planning model meet the Green OG definition would understate the number of actual acres that might be considered OG, at least at the beginning of the planning horizon.

Modeling Approach.

The planning model should be able to:

- Track the number of acres considered OG at any point in time.
- Provide the ability to control the amount of acres considered OG at any point in time.
- Reflect the impact on harvest objectives of any potential decisions to manage for OG.
- Allow for application of old growth specific regimes.
- Report on average conditions within stands considered OG at any point in time.

The strategy for tracking and controlling OG in the timber harvest scheduling model is based on the following model components.

1. Stratification

The model stratification identifies whether or not an analysis unit is comprised of acres from existing stands that have been identified as OG in the SLI. This includes stands for which the original field reconnaissance concluded that the stand is OG, as well as stands that were estimated to be OG, based on data from other SLI fields.

2. Regimes

Two sets of OG specific regimes were developed. Both sets of regimes allow periodic re-entry, and thinning of stands to a desired BA target that varies by Land Office and Potential Vegetation (PotVeg). Stands where the PotVeg is Ponderosa Pine, for example, will carry less BA than stands were PotVeg is Mixed Conifer.

The differences between the two sets of regimes are in the number of large residual trees per acre, and in the re-entry cycle. One set of regimes (the "O" regimes), leaves the minimum number of trees needed to meet the Green definition and allows re-entry on a 30 year cycle. The other set (the "P" regimes) leaves about 20 to 25% more than the minimum number of large live trees required to be labeled as old growth (or, two additional large trees per acre). Additionally, the P-regimes have been programmed with a re-entry cycle of 50 years, rather than 30 years, to allow development and retention of more old growth attributes for longer time periods thus providing for greater diversity at the landscape level.

In addition to the Old Growth regimes, the bald eagle regime will qualify a stand as old growth when applied to stands east of the continental divide. West of the divide the number of large live trees required to be labeled old growth is higher than the number retained in bald eagle regimes, or the basal area retention is higher, hence application of that regime works with some old growth types but not all types.

3. <u>OG Conditions</u>

Using the treelist associated with each yield table at each period, OG Condition coefficients (1=OG, 0=not OG) are calculated using the minimum large live tree criteria in the Green OG definitions. Each treelist is evaluated as to whether it meets the definition for each PotVeg class. In period 7, for example, a treelist might meet the OG definition where PotVeg=PP, but not where PotVeg=WP.

Within the planning model, each analysis unit can be assigned an OG condition coefficient for each period depending on the regime and the PotVeg of the analysis unit.

4. <u>OG Constraints</u>

A planning alternative with explicit OG objectives will contain three sets of constraints:

a. Allocation constraints will force the existing acres currently identified as OG to take regimes compatible with OG management.

b. Harvest constraints will allow the model to harvest a specified number of OG acres during the first 100 years of the planning horizon, if desired. These constraints might reflect, for example, the view that not all of the existing OG stands would retain stand integrity during the 175 year planning horizon. Or they might be used to reduce the number of OG acres to meet some policy objectives.

c. OG Condition constraints will require a certain number of acres to meet OG definitions from years 100-200. These constraints will allow the OG to be provided from any source – the original OG acres and/or replacement acres grown from stands that do not currently meet the definitions. Imposing these constraints starting in year 100 should minimize the problems stemming from the estimated tree ages. By year 100, trees estimated to be 70 years old today will be 170 years old.

The constraints would be applied by Land Office and by PotVeg class. The exception is that on the Stillwater and Swan State Forests old growth constraints will be applied at the Unit Office level.

5. <u>Reporting</u>

For years 1-100, the model will report on the number of existing OG acres that are managed under the OG compatible regimes, that have not yet been final harvested. Since some acres would be growing into the OG condition during this time, reporting in years 1-100 will likely understate actual acres meeting the OG definitions.

For years 100-200, the model will report on the number of acres meeting the OG condition. Some of these acres will be the existing OG acres, grown forward. Other acres may grow into the OG condition. By the years 100-200, it is expected that model reporting on the number of acres meeting the OG definition would better represent actual OG acres than reports from earlier in the modeled time-frame.

Appendix H

Sustained Yield Law, Montana Code Annotated

Appendix H
Sustained Yield Law,
Montana Code Annotated

77-5-221. Definition. As used in 77-5-222, 77-5-223, and this section, "annual sustainable yield" means the quantity of timber that can be harvested from forested state lands each year in accordance with all applicable state and federal laws, including but not limited to the laws pertaining to wildlife, recreation, and maintenance of watersheds, and in compliance with water quality standards that protect fisheries and aquatic life and that are adopted under the provisions of Title 75, chapter 5, taking into account the ability of state forests to generate replacement tree growth.

History: En. Sec. 1, Ch. 517, L. 1995.

77-5-222. Determination of annual sustainable yield. (1) The department, under the direction of the board, shall commission a new study by a qualified independent third party to determine, using scientific principles, the annual sustainable yield on forested state lands. The department shall direct the qualified independent third party to determine the yield pursuant to, but not exceeding, all state and federal laws.

(2) Until the new study required by subsection (1) is completed, the department is directed to set the annual timber sale target at 50 million board feet a year.

History: En. Sec. 2, Ch. 517, L. 1995; amd. Sec. 1, Ch. 440, L. 2003.

77-5-223. Annual sustainable yield as timber sale requirement -- review. (1) The annual sustainable yield constitutes the annual timber sale requirement for the state timber sale program administered by the department. This annual requirement may be reduced proportionately by the amount of sustained income to the beneficiaries generated by site-specific alternate land uses approved by the board.

(2) After it is determined under 77-5-222, the annual sustainable yield must be reviewed and redetermined by the department, under the direction of the board at least once every 10 years.

History: En. Sec. 3, Ch. 517, L. 1995.

Appendix I

List of Contributors

Appendix I
List of Contributors

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Brian Long, Forest Inventory Supervisor, DNRC Project Leader
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Paul Engelman, Forest Economist
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Parametrix

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Appendix J

SYC Public Involvement Process

Appendix J
SYC Public Involvement Process

Prior to Completion of SYS Calculation

DNRC staff met with environmental community on November 11, 2003; May 26, 2004; and June 4, 2004.

- Friends of the Wild Swan (FOWS)
- Montana Environmental Information Center (MEIC)
- Alliance for the Wild Rockies (AWR)
- Montana Old Growth Project (MOGP)

DNRC staff met with forest industry community.

- Montana Wood Products Association – July 17, 2003; November 25, 2003; and January 20, 2004
- DNRC Timber Sale Purchaser's Meeting on June 22, 2004

After Completion of SYS Report

- ✓ August 25, 2004 - Completion of first draft of SYS Report.

- ✓ August 27 to September 1, 2004 – Emailed, mailed and posted first draft of SYS Report on DNRC website for internal and public review.

- ✓ September 20, 2004 – Presented to the Land Board. Decision deferred until October LB Meeting.

- ✓ October 4, 2004 – Public comment period extended to October 4th as requested by the Land Board.

- ✓ October 4, 2004 – DNRC submits written responses to comments submitted by Jane Adams (MOGP) and Arlene Montgomery (FOWS).

- ✓ October 7, 2004 – David Groeschl & Paul Engelman from DNRC met with Jane Adams (MOGP) and Arlene Montgomery (FOWS) at the NWLO in Kalispell.

- ✓ October 15, 2004 – DNRC completes written responses to public comments and posts on TLMD website. Copies sent to individuals as requested.

- ✓ October 18, 2004 – SYS calculation presented to the Land Board for approval.

Appendix K

Response to Comments Most Frequently Raised During the Public Involvement Process

Appendix K
Response to Comments Most Frequently Raised During the Public Involvement Process

Following are six of the most frequent comments that were received by the DNRC regarding the Sustained Yield Study (SYS) Report. Most of the public comments mirrored those presented on the Montana Environmental Information Center (MEIC) website. C# represents the public comment or question while R# represents the DNRC response.

C1. Why the discrepancy between the biological potentials (the highest sustainable harvest level) reported in the 1996 and the 2004 SYS? The 1996 study calculated the biological potential at 58.6 MMbf while the 2004 study reported 94.6 MMbf.

R1. There are four major reasons for the difference:

- Constraint differences between Schedule A (1996) and BM001 (2004) runs
- Additional forested acres
- Updated inventory
- Different harvest schedule models

The 1996 Schedule A run, which calculated the 58.6 MMbf sustainable biological harvest level, reflects several constraints that were not applied to the BM001 run in the 2004 calculation. In the 1996 study, the coarse filter, snag and snag recruit retention, and minimum harvest flow constraints were all included in the calculation of the biological potential which reduce the potential biological yield. The 2004 study only included the minimum harvest flow constraint which was less than the minimum harvest flow constraint used in the 1996 study.

The second factor contributing to the difference between the two biological potentials is the additional acres included in the 2004 study. An additional 109,837 forested acres were added to the inventory since the 1996 study. More acres means more land growing trees which equates to a higher sustainable yield.

In addition to more acres, the Stand Level Inventory (SLI) was updated since 1996. New or updated SLI data was collected for approximately 346,000 acres in the Northwest and Southwest Land Offices since the last study in 1996. This was done to reflect changes due to fires, salvage harvesting, timber sales, planting, etc.

While both studies used similar growth models, the harvest scheduling models were different. The 2004 study used a linear programming (LP) model that looks across time (175 years) and space to find the best set of forest management strategies, given the objectives and constraints facing DNRC land managers. This modeling effort was meant to maximize sustainable revenue as present net value (PNV) while maintaining a healthy and diverse forest by selecting the <u>best</u> long-term management strategy from among a great many options or regimes. The 1996 harvest scheduling model does not include a maximization routine. It simply provides a biological harvest level predicated on the objectives and constraints given the model. In other words, the 1996 model was told to apply a specific regime to a specific stand type. The yields determined for the 1996 study were all based on limited treatment options with no ability to preferentially select a higher yielding regime instead of a lower yielding regime. The 1996 approach only provides the predicted yield given the constraints and management regimes provided to the model – not what the biological potential really is.

Since the LP model had the ability to make choices in attempting to maximize sustainable revenue (PNV) under a non-declining yield constraint, it consistently chose even-aged management regimes over uneven-aged management regimes in the early runs. This was due to the fact that uneven-aged regimes were less productive than even-aged regimes. This will be discussed in greater detail in question 3.

C2. DNRC says that its current growth is 83 MMbf/year. However, the SYS Reports states that the highest sustainable biological potential is 95 MMbf/year. DNRC provides no information to show how it will increase timber growth on State lands by 12 MMbf/year.

R2. Growth and yield are different terms with different meanings. Growth, in the context of the 83 MMbf, is the annual increase in volume per year predicted by the model before harvest. Growth is a complex function of many factors and varies from period to period. Factors that influence growth include current standing volume, current increment, future increment, management intensity, desired future conditions, and management constraints.

Two related, but distinct, definitions of growth may be confusing the issue. The definition of growth presented above, e.g., representing the accumulated change in volume across all acres, is useful for examining ownership-wide trends and effects of a sustained yield calculation. A more commonly understood definition of growth is that it represents the change in tree size from one period to the next. In the model, each stand is composed of trees grouped by size class and species. When the model is run, the trees in each size class "grow", that is they become taller, fatter and fewer (due to tree mortality) as influenced by site quality, slope, aspect, elevation, location, management and other factors. In the above paragraph this is referred to as "increment". The change in tree volume from one period to the next is summed, for each size class/species combination, and for each stand across the entire land base to determine growth at the ownership-wide scale.

Sustained yield is the amount that can be harvested in perpetuity given management (intensity and constraints), growth and standing inventory.

The 95 MMbf/year represents the highest sustainable harvest level (yield) that could be expected on State lands if the only restriction was the non-declining yield constraint as shown under BM001. (It should be noted that the 95 MMbf/year level would increase if fertilization, planting genetically improved stock, and other cultural practices were applied.)

The current <u>growth</u> of 83 MMbf/year represents the realized annual net growth in period one on commercial forested acres (668,168 acres) given our current management regimes, constraints, mitigations, mortality, and staffing levels as reflected under SYC008. The 83 MMbf growth is the period two volume divided by five minus the period one volume divided by five, plus the annual 53.2 MMbf harvest level. The current standing inventory on the State's commercial forested acres (668,168 acres) totals about 3.8 billion board feet. The annual net growth on this standing inventory from period one to period two (5 years) is projected to be about 83 MMbf under the current management regimes and constraints as represented by SYC008. Of this 83 MMbf annual net growth, 53.2 MMbf is calculated as the sustainable annual harvest level. These numbers indicate that growth exceeds harvest by about 30 MMbf annually during period one.

Since this is only a one period (5 year) snapshot, it may be more helpful and appropriate to look at the entire 175-year planning horizon. Over the entire 175-year planning horizon, annual net growth averages 81.8 MMbf which indicates that growth exceeds harvest by 28.6 MMbf annually.

The two numbers are not directly comparable since the 83MMbf represents net <u>growth</u> during period one under SYC008 whereas the 95 MMbf represents the long-term sustainable <u>yield</u> under BM001. Neither the 83 MMbf net growth during period one or the 53.2 MMbf sustainable yield are dependent on the 95 MMbf yield represented under BM001. Under our current management regimes and the proposed 53.2 MMbf harvest level, net growth exceeds harvest.

C3. How did DNRC determine that the productivity of even-age stands exceeds mixed aged stands?

R3. The DNRC did not determine this difference. This difference was demonstrated through the modeling results. Early model runs (BM001) were relatively unconstrained which allowed the model to select the management regime that would maximize the sustained revenue under the non-declining yield constraint. As stated previously, these early model runs consistently chose even-aged management regimes over uneven-aged management regimes. Average productivity in these early runs was about 142 bf/acre/year. Later runs forced acres to the uneven-aged management regimes. In these later runs, the average productivity dropped to 119-123 bf/ac/year along with an associated drop in harvest levels and PNV. In general, the uneven-aged regimes are less productive and more costly to implement and, therefore, less profitable than the even-aged regimes.

Under highly controlled (research) conditions, one might expect the yields to be similar between the two management regimes. However, growth and yields for uneven-aged forests are typically less under large-scale forest management operations due to several factors such as timing issues with achieving desired regeneration, precommercial thinnings and selection harvests, meeting residual stocking targets after each entry on a site-specific basis (too low verses too high), species specificity needs, and other operational and environmental reasons.

C4. DNRC did not take into consideration the effects of possible increased mortality on state lands due to fire, insect & disease.

R4. Mortality is captured in the model both directly and indirectly. The model uses mortality functions which account for normal, endemic levels of mortality by "killing" trees during every period (five years). The volume and growth associated with these dead trees is removed during that period and is not carried forward to future periods.

In addition to built-in mortality functions, catastrophic mortality (i.e. – fire, disease or insect outbreaks) is not explicitly modeled but is generally captured through salvage operations. This allows the substitution of dead timber for green live timber. Therefore, the volume is not lost and the salvaged stands can be regenerated and restored to a productive condition.

Major increases in mortality caused by fires and insect and disease are also reflected as the SLI inventory is updated between each sustained yield study. This updated SLI information will be used to calculate the next sustained harvest level in 10 years, or sooner if warranted. It would take a considerable event to affect the current sustainable harvest level. If a major catastrophe occurred, then another study could be done as directed by the Land Board.

The approach taken by DNRC accounts for mortality in a periodic real-time manner by accounting for endemic levels of mortality through built-in mortality functions, substituting dead volume for green volume, and continual updating of the SLI in between conducting the sustainable yield calculations every 10 years or sooner. Mortality is also reduced by maintaining healthy forests through good management.

The other approach would be to use a model, such as the SIMPPLLE Model, to predict and model disturbance regimes and its associated impact on vegetation patterns. In a recent article in the Western Journal of Applied Forestry (WJAF 19(2) 2004), the author clearly states: "*the emphasis [of this model] is on behavioral validity, not on numerical precision*." The problem with this predictive approach is trying to anticipate major events such as fire and other disturbances as "inevitable" prior to such events occurring. The SIMPPLLE Model only suggests potentials or probabilities of an event occurring – not on predicting "inevitabilities". This may have an unwarranted and predetermined effect on harvest levels which may actually exacerbate the fire, insect and disease mortality problems. Artificially lowering the harvest level due to uncertain "predicted" events would have negative results to the forests and to the trust beneficiaries by predisposing many stands to increased levels of mortality.

The current adaptive approach taken by DNRC adequately accounts for mortality using updated real-time data with periodic adjustments to harvest levels rather than a predictive disturbance approach with its own level of uncertainty.

C5. There is no accounting of the cost of logging. The state is required to make money on all of their timber sales but DNRC does not keep track of the cost of individual timber sales so they have no idea if timber sales make or lose money. From the little information DNRC provides, it looks like many of their timber sales actually lose money.

R5. For purposes of clarification, DNRC does not do the logging associated with its timber sales. These logging costs are born by the sale purchaser and are reflected in the bid prices received. DNRC does, however, incur the costs associated with sale preparation and administration. These costs constitute the bulk of our timber management program expenses. These costs are included in the model and are explicitly identified in the Sustained Yield Study Report (Section 3.1.5).

Judge Sherlock in his Order Granting Summary Judgment (#BDV-2003-527) determined that the DNRC did not have an obligation to do individual sale accounting. Furthermore, there is no legal requirement that each individual sale make money. However, a review of the yearly Return on Assets Report clearly demonstrates that the forest management program generates a net positive revenue to the trust beneficiaries. The DNRC forest management program has historically returned an average of $1.50 to $2.50 for every dollar spent.

C6. DNRC's model doesn't account for known management constraints such as seasonal-use restrictions, road construction standards, sale design parameters, and others. The model should be modified to incorporate these limitations.

R6. These issues do not affect long-term sustainable harvest levels and are handled at the project level. However, the costs associated with these management considerations are incorporated into the model parameters. The costs associated with seasonal use, road limitations, or other sale design constraints have very limited impact on DNRC costs. These costs were developed from historical agency wide information which includes the additional costs the agency has incurred as a result of these restrictions. The bulk of the costs from these kinds of restrictions are born by the timber purchasers who internalize these costs by reducing the price they are willing to pay DNRC for its timber. In addition, the sustained yield calculation accounts for road-related limitations by deferring from management forest lands that would not physically allow roads to be built and where DNRC did not have access.

Appendix L

DNRC Forest Inventory

Appendix L
DNRC Forest Inventory Data

The linear programming model selected a total of 430,800 acres of non-deferred commercial forest land to be managed using various even-aged and uneven-aged silvicultural treatments (Table L.1). Noncommercial forest land had one or both of the following characteristics: potential productivity ≤ 20 cubic feet per acre per year or forest type was classed as noncommercial.

Table L.1
DNRC Forest Land Area by Land Office and Management Category
2004 Sustained Yield Calculation

LAND OFFICE	Managed Commercial Acres	Unmanaged Commercial Acres	Non-Commercial Acres	Total Forested Acres
Northwestern Land Office	180,000	105,200	2,900	288,100
Southwestern Land Office	119,300	34,300	900	154,500
Central Land Office	74,000	33,600	9,300	116,800
Eastern Land Offices	57,600	71,200	38,400	167,200
TOTAL	430,800	244,300	51,500	726,600

There were 100,300 acres of manageable forest land that were not selected for silvicultural treatment or commercial harvest (Table L.2). Manageable forest land does not include deferred forest land, noncommercial forest land, or forest land within the grizzly bear core and buffer management zones. The following forest types may have had potential productivity ratings higher than 20 cubic feet per acre per year but were still not considered "commercial" or manageable and were not allowed to be harvested: limber pine, cottonwood, aspen, or other hardwoods.

Table L.2
Manageable DNRC Forest Land by Land Office and Management Situation,
2004 Sustained Yield Calculation

MANAGEABLE FOREST LAND	Northwestern Land Office	Southwestern Land Office	Central Land Office	Eastern Land Office	TOTAL
Managed	180,000	119,300	74,000	57,600	430,800
Not Managed	33,700	19,500	10,700	36,300	100,300
Manageable* TOTAL	213,700	138,800	84,700	93,900	531,100

*Does not include grizzly bear core or buffer forest land acres.

Table L.3 shows the standing inventory at initiation of model runs and the annual growth produced by the model for time-period one. Comparing Table 3 with Table 4 shows the strong congruency between the two independent estimates of standing volume (3.9 vs. 3.8 billion bf) and annual growth (83 million bf vs. 78 million bf).

Table L.3
DNRC Board Foot Volume and Annual Net Growth by Land Office
2004 Sustained Yield Calculation

LAND OFFICE	2004 Board Foot Scribner Volume	2004 Annual Board Foot Net Growth
Northwestern Land Office	2,445,685,000	49,143,000
Southwestern Land Office	833,015,000	19,684,000
Central Land Office	295,414,000	6,800,000
Eastern Land Offices	290,252,000	7,271,000
TOTAL	3,864,366,000	82,898,000

The following data were collected and summarized by Forest Inventory and Analysis (FIA) of the USDA Forest Service, Rocky Mountain Experiment Station, Ogden, Utah (Table L.4). The statewide inventory was conducted in Montana during the field seasons of 1988 and 1989. This data is provided as a means for comparison to the inventory estimates produced by the 2004 Sustained Yield Calculation.

Table L.4
DNRC Forest Area and Board Foot Volume by Land Office, 1988

LAND OFFICE	Timberland Acres	1988 Board Foot Scribner Volume
Northwestern Land Office	286,200	2,280,687,000
Southwestern Land Office	150,100	947,768,000
Central Land Office	93,200	401,336,000
Eastern Land Offices	87,300	128,516,000
DNRC TOTAL	616,800	3,758,307,000

Total DNRC Annual Net Growth in 1988: 78,253,000 Board Feet Scribner

Appendix M

Sample Timber Yield Tables

Appendix M
Examples of Some Yield Tables Used in the Modeling Process

This appendix contains examples of yield tables displaying board foot volumes by time period by management regime generated by the growth and yield model. Examples of yield tables are displayed for five different strata. Nearly 9,000 individual yield tables were created for several hundred strata used in the Forest Management Model.

Stratum Name	Definition
CE-DF77MM-L	Central Land Office, Douglas-fir Type, Sapling Stand, Medium Stocking, Low Site
CE-DF77MM-M	Central Land Office, Douglas-fir Type, Sapling Stand, Medium Stocking, Medium Site
NW-DL77MM-H	Northwestern Land Office, Douglas-fir/Larch Type, Sapling Stand, Medium Stocking, High Site
NW-DL77MM-L	Northwestern Land Office, Douglas-fir/Larch Type, Sapling Stand, Medium Stocking, Low Site
NW-DL77MM-M	Northwestern Land Office, Douglas-fir/Larch Type, Sapling Stand, Medium Stocking, Medium Site

CE-DF77MM-L

Land Office: CE *Riparian:* X *Site:* L Exist Initial TPA: 299.8 Acres: 1.0
Special: X *Potential Veg:* DF *Timber Type:* DF77MM Site Index: 30

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		Age (years)	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
+++++X	0	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.5	2.7	3.0	3.2	3.4	3.6
EAL076	9	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.0	1.2	1.3	1.4	1.6	1.8	1.9	2.0	2.1	2.3	2.7	2.8
		Harv		0.0																					
EAL076	10	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.1	2.1	2.6	2.8
		Harv			0.0																				
EAL076	11	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.6	2.8	2.9
		Harv				0.0																			
EAL076	12	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.5	1.7	1.9	2.0	2.1	2.6	2.7	2.9	3.0
		Harv					0.0																		
REA062	8	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.8	1.0	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.1	2.3
		Harv	0.0																						
REA062	9	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.6	1.7	1.8	1.9	2.0	2.1	2.5	2.6
		Harv		0.0																					
REA062	10	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.1	2.1	2.5	2.7
		Harv			0.0																				
REA062	11	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.7	1.8	1.9	2.0	2.1	2.5	2.7	1.6
		Harv				0.0																		1.2	
REA062	12	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.5	1.7	1.9	2.0	2.1	2.5	2.6	2.8	2.9
		Harv					0.0																		1.3
UDF052	8	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.7	1.9	0.9	1.1	1.2	1.3
		Harv	0.0																		1.0				
UDF052	9	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.6	1.7	1.8	1.9	2.0	1.0	1.3	1.4
		Harv		0.0																		1.1			
UDF052	10	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1.9	1.9	2.0	2.2	1.1	1.3
		Harv			0.0																		1.2		
UDF052	11	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.6	2.8	0.4
		Harv				0.0																		2.5	
UDF052	12	Before	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.4	1.5	1.7	1.9	0.9	0.9	1.3	1.4	1.5	1.6
		Harv					0.0											1.1							1.1

CE-DF77MM-M

Land Office: CE *Special:* X *Riparian:* X *Potential Veg:* DF *Site:* M Exist *Timber Type:* DF77MM Initial TPA: 300.1 Acres: 1.0 Site Index: 40

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
		Age (years)	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
+++++X	0	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.1	4.6	5.1	5.5	6.0	6.4	6.8	7.2	7.5	7.8	8.1
++1B+X	16	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	1.9	1.0	1.2	2.0	2.5	2.9	3.3	3.7	4.1	4.5	4.8	5.1	5.4	5.7	5.9
		Harv									1.2														
++1B+X	17	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	1.0	1.4	2.1	2.5	2.8	3.2	3.5	3.9	4.2	4.5	4.8	5.0	5.3
		Harv										1.5													
++1B+X	18	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	1.3	1.9	2.2	2.5	2.9	3.2	3.5	3.8	4.2	4.4	4.7	5.0
		Harv											1.8												
EAL076	8	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.3	2.6	3.0	3.8	4.3	4.6	4.9	5.1	5.3	5.6	4.9	5.2	5.5	5.6
		Harv	0.0																		1.1				
EAL076	9	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.7	3.1	3.9	4.3	4.7	5.1	5.3	5.5	5.8	6.1	5.1	5.5	5.6
		Harv		0.0																		1.3			
EAL076	10	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.0	4.4	4.7	5.1	5.5	5.7	5.9	6.2	6.4	5.3	5.7
		Harv			0.0																		1.5		
EAL076	11	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.0	4.4	4.8	5.2	4.4	4.8	5.1	5.4	5.7	6.0	6.3
		Harv				0.0												1.2							
EAL076	12	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.1	4.5	4.8	5.2	5.6	4.5	4.9	5.3	5.6	5.9	6.2
		Harv					0.0												1.4						
REA062	8	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.3	2.6	3.0	3.8	2.4	2.6	2.9	3.1	3.3	3.6	3.8	4.0	4.2	4.3
		Harv	0.0												1.8										
REA062	9	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.7	3.1	4.0	4.4	2.5	2.8	3.1	3.3	3.5	3.8	3.9	4.1	4.2
		Harv		0.0												2.1									
REA062	10	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.0	4.4	4.7	2.7	2.9	3.2	3.4	3.7	3.9	4.1	4.2
		Harv			0.0												2.4								
REA062	11	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.1	4.4	4.8	5.2	2.8	3.0	3.2	3.5	3.7	4.0	4.1
		Harv				0.0												2.6							
REA062	12	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.8	3.2	4.1	4.5	4.9	5.3	5.6	2.9	3.2	3.4	3.6	3.8	4.0
		Harv					0.0												3.0						
REA082	8	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.3	2.6	3.0	3.8	3.2	3.5	3.9	4.1	4.4	4.6	4.9	5.2	5.3	5.5
		Harv	0.0												1.0										
REA082	9	Before	0.0	0.0	0.0	0.2	0.3	0.8	1.1	1.5	2.0	2.4	2.7	3.1	4.0	4.4	3.4	3.8	4.1	4.3	4.6	4.9	5.2	5.4	5.6
		Harv		0.0												1.3									

NW-DL77MM-H

Land Office: NW *Special:* X *Riparian:* X *Potential Veg:* DL *Site:* H Exist *Timber Type:* DL77MM Initial TPA: 299.7 Acres: 1.0 Site Index: 70

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		Age (years)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
+++++X	0	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	16.6	17.5	18.1	18.6	19.1	19.8	20.2	20.6	21.0
++1B+X	15	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	5.1	5.6	6.0	6.5	6.9	7.2	7.5	7.9	8.2	8.6	8.9
		Harv												9.1											
++1B+X	16	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	5.3	5.7	6.1	6.4	6.8	7.0	7.4	7.7	8.1	8.4
		Harv													9.9										
++1B+X	17	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	6.4	6.8	7.2	7.5	7.8	8.2	8.5	8.8	9.2
		Harv														9.7									
++1B+X	18	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	16.6	6.6	6.9	7.2	7.5	7.9	8.2	8.5	8.8
		Harv															10.4								
+41B+X	15	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	6.1	6.7	7.2	7.7	8.1	8.4	8.7	9.1	9.3	9.5	9.8
		Harv												8.2											
+41B+X	16	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	6.2	6.7	7.2	7.6	7.9	8.2	8.6	8.8	9.0	9.4
		Harv													9.0										
+41B+X	17	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	6.4	6.8	7.2	7.5	7.8	8.2	8.5	8.8	9.2
		Harv														9.7									
+41B+X	18	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	16.6	6.6	6.9	7.2	7.5	7.9	8.2	8.5	8.8
		Harv															10.4								
+6+++X	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	16.6	17.5	18.1	18.6	19.1	19.8	20.2	20.6	21.0
+61B+X	15	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	6.1	6.7	7.2	7.7	8.1	8.4	8.7	9.1	9.3	9.5	9.8
		Harv												8.2											
+61B+X	16	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	6.2	6.7	7.2	7.6	7.9	8.2	8.6	8.8	9.0	9.4
		Harv													9.0										
+61B+X	17	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	6.4	6.8	7.2	7.5	7.8	8.2	8.5	8.8	9.2
		Harv														9.7									
+61B+X	18	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.7	16.6	6.6	6.9	7.2	7.5	7.9	8.2	8.5	8.8
		Harv															10.4								
EAL076	4	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.7	12.0	12.8	13.4	10.9	11.6	11.7	12.6	13.2	13.8	10.0	10.5	11.0	11.5
		Harv	0.0												3.2						4.4				
EAL076	5	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	8.3	9.8	10.8	11.6	12.1	12.5	11.0	11.5	11.3	12.2	12.7	13.4	9.8	10.4	10.8
		Harv		0.0						1.1						2.1						4.0			

NW-DL77MM-H

Land Office: NW *Riparian:* X *Site:* H Exist Initial TPA: 299.7 Acres: 1.0
Special: X *Potential Veg:* DL *Timber Type:* DL77MM Site Index: 70

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		Age (years)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
EAL076	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	8.6	10.0	11.0	11.5	11.9	12.2	11.1	11.3	11.1	11.9	12.4	13.0	9.7	10.3
		Harv			0.0						2.1						1.6						3.8		
EAL076	7	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	9.3	10.3	10.9	11.4	11.7	11.9	11.0	11.0	10.8	11.7	12.1	12.6	9.5
		Harv				0.0						2.9						1.0						3.7	
EAL076	8	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	9.6	10.4	10.9	11.3	11.5	11.5	11.6	11.4	11.3	12.1	12.5	13.0
		Harv					0.0						3.7												4.1
RNW104	4	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	11.0	12.7	13.9	15.1	12.2	13.1	13.6	14.4	15.1	15.8	12.1	12.8	13.3	13.9
		Harv	0.0												3.8						4.5				
RNW104	5	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.6	13.9	15.0	16.0	12.6	13.5	13.8	14.5	15.2	16.1	12.1	12.8	13.3
		Harv		0.0												4.3						4.7			
RNW104	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	15.8	16.6	12.9	13.6	13.9	14.5	15.4	16.1	12.1	12.8
		Harv			0.0												4.5						4.7		
RNW104	7	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	10.7	11.8	12.8	13.8	14.7	15.6	12.9	13.3	13.4	14.1	14.6	15.2	11.8
		Harv				0.0						1.7						3.1						3.9	
RNW104	8	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	11.0	11.9	12.8	13.7	14.5	15.1	12.9	13.2	13.4	14.0	14.5	15.0
		Harv					0.0						2.5						2.5						3.8
RNW164	4	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	11.1	12.8	14.2	15.4	16.6	17.7	18.3	18.7	19.3	19.8	20.6	21.1	21.5	21.9
		Harv	0.0																						
RNW164	5	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.7	14.1	15.4	16.6	17.6	18.6	18.9	19.3	19.8	20.6	21.1	21.6	22.0
		Harv		0.0																					
RNW164	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.9	15.2	16.4	17.4	18.6	19.2	19.5	19.8	20.5	20.9	21.4	21.9
		Harv			0.0																				
RNW164	7	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	15.0	16.2	17.3	18.6	19.2	19.8	20.1	20.7	21.1	21.5	22.0
		Harv				0.0																			
RNW164	8	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	12.4	13.7	14.8	16.0	17.0	18.2	18.9	19.4	20.0	20.5	20.8	21.2	21.6
		Harv					0.0																		
ULF084	4	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	2.1	2.6	3.3	3.7	4.1	4.5	4.8	4.9	6.5	7.5	8.6	9.9	5.5	5.7	6.0	6.2
		Harv	0.0						5.0												4.7				
ULF084	5	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	2.5	3.2	3.6	4.1	4.5	4.8	5.1	5.3	6.9	7.9	9.0	10.5	5.8	6.1	6.4
		Harv		0.0						6.1												4.9			

NW-DL77MM-H

Land Office: NW *Riparian:* X *Site:* H Exist Initial TPA: 299.7 Acres: 1.0

Special: X *Potential Veg:* DL *Timber Type:* DL77MM Site Index: 70

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		Age (years)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
ULF084	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	3.0	3.5	4.0	4.4	4.7	5.0	5.3	5.3	6.9	7.9	9.1	10.4	5.7	6.1
		Harv			0.0						7.2												5.0		
ULF084	7	Before	0.0	0.4	0.9	2.2	1.6	2.9	4.0	5.1	6.5	7.6	3.8	4.3	4.7	5.1	5.5	6.0	6.3	6.3	7.7	8.6	9.7	10.9	6.3
		Harv				1.2						4.4												4.8	
ULF084	8	Before	0.0	0.4	0.9	2.2	3.4	2.5	3.4	4.4	5.5	6.4	7.2	4.1	4.5	4.9	5.3	5.6	6.2	5.0	5.2	6.3	6.9	7.7	8.6
		Harv					2.0						3.7						1.4						2.8
UMC124	4	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	3.3	4.0	4.9	5.5	6.0	6.5	6.8	7.0	7.0	8.5	9.5	10.3	7.5	7.9	8.4	9.0
		Harv	0.0						4.1												3.4				
UMC124	5	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	3.9	4.8	5.4	6.1	6.5	6.8	7.1	7.4	7.2	8.7	9.5	10.4	7.5	8.0	8.6
		Harv		0.0						5.0												3.3			
UMC124	6	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	4.7	5.4	6.0	6.5	6.8	7.1	7.4	7.5	7.3	8.7	9.5	10.4	7.5	7.9
		Harv			0.0						5.9												3.3		
UMC124	7	Before	0.0	0.4	0.9	2.2	3.4	4.9	6.6	8.1	9.6	10.9	5.2	5.8	6.3	6.7	7.0	7.4	7.5	7.5	7.2	8.7	9.5	10.3	7.4
		Harv				0.0						6.6												3.3	
UMC124	8	Before	0.0	0.4	0.9	2.2	3.4	3.5	4.9	6.0	7.2	8.6	9.6	5.9	6.4	6.9	7.3	7.6	7.8	7.8	7.8	7.6	8.9	9.6	10.3
		Harv					1.0						4.3												3.1

NW-DL77MM-L

Land Office: NW *Special:* X *Riparian:* X *Potential Veg:* DL *Site:* L Exist *Timber Type:* DL77MM Initial TPA: 300.2 Acres: 1.0 Site Index: 50

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		Age (years)	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
+++++X	0	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.5	7.1	7.8	8.3	8.9	9.3	9.8	10.1	10.5	10.8	11.3
+5+++X	5	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.5	7.1	7.8	8.3	8.9	9.3	9.8	10.1	10.5	10.8	11.3
+7+++X	7	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.5	7.1	7.8	8.3	8.9	9.3	9.8	10.1	10.5	10.8	11.3
EAL076	5	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.5	4.1	4.6	5.1	6.2	6.8	7.1	7.3	7.5	7.9	6.8	7.8	8.1	8.6
		Harv	0.0																		1.2				
EAL076	6	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	4.8	6.0	6.5	7.0	7.4	7.7	7.9	8.2	8.3	7.0	8.0	8.4
		Harv		0.0																		1.5			
EAL076	7	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	4.9	6.1	6.6	7.1	7.5	7.8	8.0	8.3	8.4	8.6	7.1	8.2
		Harv			0.0																		1.6		
EAL076	8	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.3	6.8	7.3	7.7	6.7	7.0	7.2	7.3	7.5	7.6	7.9
		Harv				0.0												1.2							
EAL076	9	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.5	7.0	7.5	7.9	8.2	6.8	7.1	7.3	7.4	7.5	7.7
		Harv					0.0												1.6						
RNW104	5	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.5	4.2	4.7	5.2	6.4	6.9	7.3	7.5	7.7	8.1	8.3	9.0	9.3	9.8
		Harv	0.0																						
RNW104	6	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	4.9	6.2	6.7	7.3	7.8	8.0	8.2	8.5	8.7	8.8	9.5	9.9
		Harv		0.0																					
RNW104	7	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	4.9	6.2	6.7	7.3	7.8	8.1	8.3	8.7	8.8	9.0	9.1	9.9
		Harv			0.0																				
RNW104	8	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.3	6.9	7.4	7.9	7.1	7.5	7.8	8.1	8.3	8.6	8.9
		Harv				0.0												1.2							
RNW104	9	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.5	7.0	7.6	8.1	8.4	7.3	7.8	8.0	8.3	8.5	8.9
		Harv					0.0												1.6						
RNW164	6	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	4.9	6.2	6.8	7.4	7.9	8.2	8.5	8.8	9.1	9.3	9.5	10.0
		Harv		0.0																					
RNW164	7	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.3	6.3	6.9	7.5	8.0	8.4	8.7	9.0	9.3	9.5	9.7	10.0
		Harv			0.0																				
RNW164	8	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	5.4	6.3	6.9	7.5	8.0	8.4	8.8	9.2	9.4	9.6	9.9	10.2
		Harv				0.0																			
ULF084	5	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	0.9	1.2	1.5	1.8	2.1	2.8	1.1	1.2	1.4	1.5	1.6	2.4	2.8	3.3	3.7	4.2
		Harv	0.0						1.1						2.0										

NW-DL77MM-L

Land Office: NW *Special:* X *Riparian:* X *Potential Veg:* DL *Site:* L Exist *Timber Type:* DL77MM Initial TPA: 300.2 Acres: 1.0 Site Index: 50

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		Age (years)	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
ULF084	6	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	1.2	1.5	1.8	2.1	3.3	3.5	1.2	1.4	1.5	1.6	1.7	1.8	2.8	3.1	3.6
		Harv		0.0						1.5						2.5									
ULF084	7	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	1.5	1.8	2.6	3.3	3.6	3.9	1.4	1.5	1.6	1.7	1.8	1.9	2.9	3.3
		Harv			0.0						1.8						2.7								
ULF084	8	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.6	1.8	2.5	3.2	3.5	3.8	4.0	1.5	1.6	1.8	1.9	2.0	2.1	3.1
		Harv				0.0						2.2						2.6							
ULF084	9	Before	0.0	0.0	0.0	0.2	0.5	1.2	1.8	2.4	3.0	3.7	4.3	2.4	3.1	3.4	3.8	4.0	4.2	1.6	1.7	1.8	2.0	2.0	2.1
		Harv					0.0						2.6						2.7						

NW-DL77MM-M

Land Office: NW *Riparian:* X *Site:* M Exist Initial TPA: 299.9 Acres: 1.0
Special: X *Potential Veg:* DL *Timber Type:* DL77MM Site Index: 60

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		Age (years)	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
+++++X	0	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.4	10.1	10.7	11.1	11.6	12.1	12.5	12.9	13.2	13.7
++1B+X	15	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	6.9	3.1	3.4	3.7	4.1	4.3	4.6	4.8	5.0	5.2	5.3	5.6	5.8
		Harv											4.4												
++1B+X	16	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	7.9	3.3	3.5	3.9	4.1	4.4	4.6	4.8	4.9	5.1	5.3	5.5
		Harv												5.0											
++1B+X	17	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	4.0	4.4	4.6	4.8	5.0	5.2	5.4	5.5	5.8	6.0
		Harv													5.0										
++1B+X	18	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.4	4.2	4.4	4.6	4.8	5.0	5.2	5.3	5.6	5.8
		Harv														5.6									
+51B+X	18	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.4	3.8	4.0	4.3	4.5	4.7	4.8	5.0	5.2	5.4
		Harv														5.9									
+7+++X	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.4	10.1	10.7	11.1	11.6	12.1	12.5	12.9	13.2	13.7
+71B+X	16	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	3.5	3.8	4.2	4.5	4.7	4.9	5.1	5.2	5.4	5.7	5.9
		Harv												4.8											
+71B+X	17	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	3.7	4.0	4.3	4.5	4.7	4.9	5.0	5.2	5.5	5.7
		Harv													5.3										
+71B+X	18	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.4	3.8	4.0	4.3	4.5	4.7	4.8	5.0	5.2	5.4
		Harv														5.9									
EAL076	5	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.0	6.7	7.3	8.0	8.4	8.9	9.0	9.1	9.9	10.6	7.0	7.6	8.0	8.6
		Harv	0.0																		4.0				
EAL076	6	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	6.8	7.8	8.3	8.6	9.0	9.4	9.4	9.4	9.6	10.7	7.1	7.6	8.1
		Harv		0.0																		4.1			
EAL076	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	7.9	8.4	8.8	9.2	9.4	9.6	9.6	9.8	9.8	10.9	7.1	7.7
		Harv			0.0																		4.3		
EAL076	8	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.5	9.0	9.4	9.6	9.7	10.0	10.0	10.0	10.0	11.1	7.2
		Harv				0.0																		4.4	
EAL076	9	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.2	9.6	9.9	10.0	9.0	9.4	9.3	9.3	9.3	10.3
		Harv					0.0												1.1						3.7
RNW104	5	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.2	8.0	9.0	9.7	10.5	10.8	11.1	11.9	12.6	9.8	10.5	11.1	11.9
		Harv	0.0																		3.6				

NW-DL77MM-M

Land Office: NW *Special:* X *Riparian:* X *Potential Veg:* DL *Site:* M Exist *Timber Type:* DL77MM Initial TPA: 299.9 Acres: 1.0 Site Index: 60

		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		Age (years)	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
RNW104	6	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.1	8.3	9.1	9.8	10.6	11.2	11.5	11.8	12.2	13.1	9.9	10.8	11.5
		Harv		0.0																		3.9			
RNW104	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.1	9.0	9.7	10.5	11.1	11.7	12.0	12.4	12.7	13.6	9.9	11.0
		Harv			0.0																		4.2		
RNW104	8	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.8	9.6	10.5	11.1	10.5	11.1	11.5	11.8	12.1	13.0	10.1
		Harv				0.0												1.2						3.6	
RNW104	9	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.5	10.4	11.1	11.6	10.6	11.4	11.7	11.9	12.2	13.1
		Harv					0.0												1.5						3.4
RNW164	5	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.2	7.2	8.4	9.3	10.1	11.0	11.5	11.9	12.3	13.0	13.5	13.9	14.3	14.8
		Harv	0.0																						
RNW164	6	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.1	8.3	9.3	10.1	11.1	11.8	12.2	12.6	13.3	13.8	14.1	14.6	15.1
		Harv		0.0																					
RNW164	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.2	9.1	10.0	10.9	11.6	12.3	12.7	13.2	13.6	14.1	14.5	15.1
		Harv			0.0																				
RNW164	8	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.8	9.8	10.7	11.4	12.1	12.7	13.4	13.7	14.1	14.3	15.1
		Harv				0.0																			
RNW164	9	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	8.0	8.7	9.6	10.5	11.4	12.1	12.7	13.5	13.9	14.4	14.8	15.2
		Harv					0.0																		
ULF084	5	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	1.1	1.4	1.8	2.1	2.4	2.6	2.9	3.0	3.1	4.3	5.1	6.0	3.0	3.0	3.2	3.3
		Harv	0.0						2.5												3.1				
ULF084	6	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	1.4	1.6	2.1	2.4	2.6	2.8	3.1	3.1	3.2	4.4	5.1	6.0	3.1	3.2	3.3
		Harv		0.0						3.2												3.1			
ULF084	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	1.5	2.0	2.3	2.5	2.7	3.0	3.1	3.2	3.2	3.4	4.9	5.7	3.1	3.3
		Harv			0.0						4.0												2.6		
ULF084	8	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	1.9	2.2	2.5	2.7	3.0	3.1	3.3	3.3	3.4	3.5	5.2	5.9	3.4
		Harv				0.0						4.6												2.7	
ULF084	9	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	7.0	2.1	2.4	2.6	2.9	3.0	3.2	3.3	3.4	3.4	3.4	5.1	5.9
		Harv					0.0						5.3												2.4
UMC124	5	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	1.6	2.0	2.4	2.9	3.3	3.6	3.8	4.0	3.9	3.9	5.1	5.9	4.3	4.7	5.1	5.6
		Harv	0.0						2.1												2.0				

NW-DL77MM-M

Land Office: NW *Riparian:* X *Site:* M Exist Initial TPA: 299.9 Acres: 1.0

Special: X *Potential Veg:* DL *Timber Type:* DL77MM Site Index: 60

			2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Year	2006	2011	2016	2021	2026	2031	2036	2041	2046	2051	2056	2061	2066	2071	2076	2081	2086	2091	2096	2101	2106	2111	2116
		Age (periods)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		Age (years)	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
UMC124	6	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.3	2.0	2.4	3.0	3.3	3.6	3.8	4.0	4.1	4.1	4.0	3.9	5.6	4.3	4.7	5.1
		Harv		0.0						2.6												1.6			
UMC124	7	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	2.3	2.8	3.3	3.6	3.8	4.1	4.2	4.3	4.2	4.1	4.9	5.9	4.4	4.8
		Harv			0.0						3.3												1.9		
UMC124	8	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	2.7	3.2	3.5	3.8	4.0	4.2	4.3	4.3	4.3	4.2	4.0	5.7	4.5
		Harv				0.0						3.8												1.6	
UMC124	9	Before	0.0	0.1	0.3	0.9	1.5	2.1	3.4	4.2	5.2	6.1	6.9	3.2	3.5	3.7	4.0	4.2	4.3	4.3	4.4	4.3	4.2	4.1	5.7
		Harv					0.0						4.3												1.5